Summer 2018

Exploring the Moderating Effects of Family Functioning and Child Grit on the Relation between ADHD Endophenotypes and ADHD Symptoms

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Exploring the Moderating Effects of Family Functioning and Child Grit on the Relation between ADHD Endophenotypes and ADHD Symptoms

by

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A Dissertation
Submitted to the Graduate School,
the College of Education and Psychology,
and the Department of Psychology
at The University of Southern Mississippi
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy

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December 2018

Published by the Graduate School

ABSTRACT

ADHD is a heritable condition, with unknown etiologies and different phenotypic expressions in affected individuals. Its genetic vulnerability may be expressed only when specific environmental conditions are present. Endophenotypes stand in the causal path between genes and disease and are found in children diagnosed with ADHD as well as unaffected relatives. This study investigated the link between ADHD endophenotypes and the heterogeneous expression of ADHD symptoms in 84 children aged 11 to 17 years and explored whether this relation depends on family functioning and resilience of the child (i.e., grit). It was hypothesized that (1) ADHD endophenotypes would be moderately positively related to ADHD symptoms, (2) poorer family functioning would be positively related to ADHD symptoms, (3) grit would be negatively related to ADHD symptoms, (4) poorer family functioning would exacerbate the relation between ADHD endophenotypes and child ADHD symptoms, (5) grit would attenuate the relation between ADHD endophenotypes and ADHD symptoms, (6) grit would attenuate the relation between family functioning and ADHD symptoms, and (7) the influence of family functioning on endophenotypes' effect on ADHD symptoms would depend on grit so that the magnitude of the effect of endophenotypes on ADHD symptoms in families with poorer functioning would be smaller for children with higher levels of grit. There was partial support for the first five hypotheses. Expected significant correlations between ADHD endophenotypes and parent- and teacher-rated ADHD domains were found. Results indicated a positive relation between family dysfunction and teacher-rated ADHD symptoms, whereas child grit was negatively associated with parent-rated ADHD domains. Some significant interactions emerged. Family dysfunction exacerbated the relation between response disinhibition and parent-rated ADHD domains. Child grit moderated the relation between response disinhibition and teacher-rated ADHD domains, albeit in a way somewhat contrary to predictions. There was a trend toward child grit attenuating the relation between deficits in working memory and parent-rated hyperactivity/impulsivity. The three-way interaction between response disinhibition, family dysfunction, and child grit was significant indicating that the effect of higher family dysfunction on the relation between response disinhibition and teacher-rated inattention was stronger for grittier children. Limitations and conclusions of this study are discussed.

ACKNOWLEDGMENTS

I would like to thank Dr. Tammy D. Barry for her guidance, support, and assistance. I also would like to thank my committee members, Dr. Sara Jordan, Dr. Christopher Barry, and Dr. D. Joe Olmi for their suggestions.

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CHAPTER I - INTRODUCTION

Attention-deficit/hyperactivity disorder (ADHD) is a mental health disorder that encompasses patterns of inattention, hyperactivity, and impulsivity in approximately 5% of children and 2.5% of adults. Individuals with this diagnosis are at-risk for lifelong problems including low academic achievement and occupational difficulties, internalizing symptoms (e.g., anxiety, depression), social deficits (e.g., poor interpersonal relations, conflicts in social relationships, marital struggles), and externalizing behaviors (e.g., aggression, conduct problems, substance abuse, DSM-5; APA, 2013). Early identification and treatment could lessen both ADHD symptoms and the associated negative outcomes (Sonuga-Barke & Halperin, 2010).

ADHD as a Dimensional Construct

The DSM-5 (APA, 2013) defines ADHD as a categorical diagnosis with symptoms of inattention and hyperactivity/impulsivity. However, several studies highlight the strengths of a dimensional view of ADHD as a mental disorder in both clinical and general populations (Frazier, Youngstrom, & Naugle, 2007; Haslam et al., 2006; Marcus & Barry, 2011). For example, approaching the symptoms of the disorder as on a continuum facilitates accuracy of the evaluation due to greater reliability and validity (MacCallum, Zhang, Preacher, & Rucker, 2002). Greater variability of the individual differences also provides important additional information about functionally-impaired individuals with subclinical symptoms of ADHD who likely would get screened out of beneficial treatment if a categorical conceptualization is employed exclusively (Frazier et al., 2007). In addition, different interventions and services may be applicable or effective for individuals presenting with moderate versus more severe symptoms of

ADHD, which could be differentiated using a dimensional view of ADHD (Frazier et al., 2007). Consideration of a dimensional structure of psychopathology also benefits research that aims to elucidate multiple etiologies (Frazier et al., 2007; Haslam, 1997) as well as moderating or situational factors (Beauchaine, 2003) of mental health syndromes, which is applicable to the aims of the current study. Evidence for a dimensional model of ADHD was also presented in a large general population study of the latent structure of the disorder by Marcus and Barry (2011). Specifically, they found that inattention as well as hyperactivity and impulsivity difficulties reported by parents and teachers (including specific indicators of ADHD measured by objective laboratory tasks or standardized tests) are best conceptualized as being on a continuum.

Endophenotypes

Endophenotypes (or immediate phenotypes) can be defined as behaviors or cognitions that are linked to functional deficits in neural brain clusters, are seen in first degree relatives of individuals suffering from a disorder, and whose early detection can allow interventions before the full-blown symptoms are observed (Robbins, Gillan, Smith, de Wit, & Ersche, 2012). Endophenotypes stand between genes and the disorder and can be detected regardless of the presence or absence of observable, behavioral symptoms (McAuley, Crosbie, Charach, & Schachar, 2014). They are associated with genetic vulnerability for the disorder (Rommelse, Altink, Oosterlaan et al., 2008). This susceptibility of genes can express itself via subtle neuropsychological aberrations that can be demonstrated and measured via neuropsychological computer tasks (Rommelse, Altink, Oosterlaan et al., 2008). Endophenotypes are considered an expression of genetic liability for the disease (Doyle, Willcutt et al., 2005). They are less heterogeneous than phenotypes because of their closer proximity to genes in the path from genes to phenotype (Doyle, Willcutt et al., 2005).

In recent years, neuropsychological, neuroimaging, and electrophysiological endophenotypes have been gaining increased attention in research (Gau & Shang, 2010). Endophenotypes could address one criticism of the DSM-5, for which criteria for diagnoses are based not on biological etiology but, rather, on descriptions of behaviors and functions of these behaviors (Robbins et al., 2012). The focus of the current study was to add to the literature by examining the relation between specific endophenotypes and symptoms of ADHD, including how that link may be impacted by environment (i.e., family functioning) and child individual differences (i.e., levels of grit).

ADHD and Endophenotypes

ADHD is a heritable developmental mental illness with reported heritability ranging from 60% to 80 % (Thapar, O'donovan, & Owen, 2005). ADHD symptoms are not static but often change over time (Rommelse, Oosterlaan, Buitelaar, Faraone, & Sergeant, 2007). In one study, self-reported ADHD symptoms in mothers were significantly related to child inattention in boys 7 years of age (Auerbach, Zilberman-Hayun, Atzaba-Poria, & Berger, 2017). Nigg et al. (2018) found that genetic vulnerability expressed via a polygenic risk score was significantly positively related with ADHD symptoms reported by parents and teachers as well as with the diagnosis of ADHD in children. Parents with symptoms of ADHD represent a risk factor and may influence their child’s reported ADHD symptoms over time (Moroney, Tung, Brammer, Peris, & Lee, 2017). Specifically, Moroney et al. (2017) found that changes in self-reported parent

ADHD symptoms across 6 years were positively related to changes in parents' reports of ADHD symptoms of their children.

The expression of the genes implicated in ADHD and their effect is not constant throughout the child's growth and depends on the influence of the environment or other genes that may or may not be expressed at different points of a child's or adult's life (Rommelse et al., 2007). It has been reported that some ADHD phenotypes can disappear over time if other brain areas maturate and are able to compensate for some of the ADHD behavioral deficits (Halperin & Schulz, 2006). However, even in these instances, ADHD endophenotypes, which are thought to have a genetic basis, are still measurable in children or adults with a prior ADHD diagnosis and are not outgrown despite the improvement in phenotypic expression of ADHD due to brain development (Rommelse et al., 2007).

ADHD neuropsychological endophenotypes are heritable, associated with the disorder and found also in first-degree unaffected relatives of impaired individuals (Rommelse, Altink, Martin et al., 2008). Measures to assess neuropsychological endophenotypes are relatively inexpensive and easy to administer via neuropsychological computer tasks (Doyle, Willcutt et al., 2005), which are designed to measure a single process (e.g.; inhibition; Sergeant, Geurts, & Oosterlaan, 2002). For example, individuals with ADHD perform poorly on neuropsychological tests of executive function, which are presumed to be mediated by frontal circuits (Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005).

A twin study by Bidwell, Willcutt, DeFries, and Pennington (2007) investigated performance of their participants on an extensive battery of neuropsychological measures. They found that cotwins of children diagnosed with ADHD, who did not display ADHD symptoms themselves, showed significantly worse performance on 16 out of 18 of these measures compared to control participants. Their results also showed that ADHD probands and their unaffected cotwins did not differ in their deficits despite accounting for the subclinical ADHD symptoms. Endophenotypes are more closely associated with the genetic makeup of an individual than more heterogeneous ADHD behavioral symptoms and may provide important information about the etiology of this neurodevelopmental disorder (van Ewijk et al., 2014), because they increase the ability to detect the influence of individual genes on the variance of ADHD symptoms. Prior studies have established several neuropsychological endophenotypes for ADHD, including response inhibition (Goos, Grosbie, Payne, & Schachar, 2009), intra-individual reaction time variability (Lin, Hwang-Gu, & Gau, 2015), and working memory (Gau & Shang, 2010). These three ADHD endophenotypes were the focus of the current study.

Response Inhibition

Response inhibition has been conceptualized as the capability of an individual to withhold a response (Barkley, 1997). Response inhibition has been recognized as a neuropsychological endophenotype in both children and adults with ADHD (Robbins et al., 2012; Slaats-Willemse, Swaab-Barneveld, De Sonneville, van der Meulen, & Buitelaar, 2003). According to McAuley et al. (2014), the response inhibition endophenotype detected in children can be found in adolescents 5 years later despite the abatement of the ADHD phenotype, meaning that adolescents no longer demonstrate behavioral symptoms of ADHD.

Rommelse, Altink, Oosterlaan et al. (2008) established behavioral inhibition as an endophenotype via a stop task administered to children diagnosed with ADHD as well as to both their affected and nonaffected siblings. The researchers found that the stop signal reaction time and the percentage of commission errors significantly differed in ADHD probands and their affected and nonaffected siblings when compared to controls, suggesting that the behavioral inhibition endophenotype is present among families impacted by ADHD regardless of the specific child's ADHD diagnosis.

Prior research suggests that behavioral disinhibition in children may be the result of inferior time estimation abilities and difficulties judging time intervals in an unstructured environment (Sonuga-Barke, Saxton, & Hall; 1998). More specifically, in the Sonuga-Barke et al. study, hyperactive boys responded prematurely to the stimulus because they underestimated the time interval of when the change in the presented stimulus would happen. Another study found that when participants with ADHD are asked to reproduce a time interval of 12 seconds, they exchange speed for accuracy, which leads to their impulsive responding and inability to discriminate the time interval correctly (Smith, Taylor, Rogers, Newman, & Rubia, 2002).

Indeed, other research supports the notion that children diagnosed with ADHD have an impaired subjective sense of time (Kerns, McInerney, & Wilde, 2001; Meaux & Chelonis, 2003). For example, compared to 21 matched controls, 21 children with an ADHD diagnosis made significantly more errors when estimating a 3- to 17-second time interval during which a computer light was turned on, and the effect was stronger as the time duration interval increased (Kerns, McInerney, & Wilde, 2001). These true time reproduction deficits persist regardless of the changes in children's motivations

(McInerney & Kerns, 2003). More specifically, compared to control participants, participants with ADHD estimated longer duration times when the actual duration was for a shorter period of time, and they estimated shorter duration times when the actual duration was for a longer period of time.

Methylphenidate seems to ameliorate timing deficits within the ADHD population (Baldwin et al., 2004). In the study by Baldwin and colleagues, children were asked to hold a lever for at least 10 seconds but not longer than 14 seconds and received nickels if they judged the time interval correctly. Children diagnosed with ADHD who received methylphenidate demonstrated decreased response variability (differences in the standard deviations of the mean level hold durations); they also demonstrated significantly decreased short non-reinforced lever holds (below the minimum) and increased correct reinforced lever holds when compared to children with an ADHD diagnosis who did not receive the medication. This pattern suggests impairment of frontal neural circuits that are responsible for executive function deficits including behavioral disinhibition among individuals diagnosed with ADHD (Barkley, 1997). Behavioral disinhibition and hyperactivity, which are characteristic of the ADHD population, are often treated with stimulant medication (Nafees et al., 2014).

Reaction Time (RT) Variability

Reaction time (RT) variability measures the ability to consistently respond to a presented stimulus (Doyle, Willcutt et al., 2005) and is thought to decrease abruptly between the ages of 6 and 20 years (Belle, Hulst, & Durston, 2015). It is typically indexed as differences in mean RTs of an individual responding to a stimulus; when compared to control participants, significantly higher intra-individual differences are found in children with an ADHD diagnosis—as well as their nonaffected siblings, although to a lesser extent (McAuley et al., 2014; Uebel et al., 2008). Adamo et al. (2014) found that children with ADHD demonstrated significantly increased RT variability compared to typically-developing children on both of their study's cognitive tasks (i.e., Eriksen Flanker Task and sustained attention to response task, which is a version of a Go/No Go task). Developmental changes in RT variability have been demonstrated in the ADHD population, suggesting it can be considered as a marker for neural development (Belle et al., 2015).

Working Memory

Verbal working memory is the ability to keep and work with information in short-term memory (Baddeley, 1992). Working memory was also confirmed as an ADHD endophenotype (Rommelse, Altink, Oosterlaan et al., 2008). In the latter study, 5- to 19-year-old children diagnosed with ADHD, as well as their affected and non-affected siblings and control children, were tested on working memory via digit span forward and digit span backward tasks on the WISC-III. Probands, as well as both affected and nonaffected sibling participants, showed significant deficits in their working memory capacity compared to controls. Unaffected siblings of children diagnosed with ADHD are valuable in ADHD research given that they share 50% of the genetic vulnerability for ADHD symptoms but do not exhibit significant inattention, hyperactivity, and/or impulsivity (van Ewijk et al., 2014). Other studies also found that children diagnosed with ADHD perform worse on working memory tests than unaffected siblings who perform worse than controls (Gau & Shang, 2010; McAuley et al., 2014). Nigg et al. (2018) found that working memory, measured via digit span forward and digit span backward tasks on the WISC-IV, mediated the relation between genetic vulnerability for ADHD as well as the expression of ADHD symptoms in children between 7 and 11 years old.

Family Functioning and ADHD

Genes are expressed with the help of the environment and development (Rutter, Moffitt, & Caspi, 2006). Children's behavioral problems are linked to negative family environment such as family conflict, marital dissatisfaction, and inability to express feelings openly (Biederman, Faraone, & Monuteaux, 2002; Drabick, Gadow, & Sprafkin, 2006; Lucia & Breslau, 2006), and higher cohesion in families predicts lower externalizing and internalizing symptoms in children (Henderson, Sayger, & Horne, 2003). In a study by Auerbach et al. (2017), 7-year-old boys who lived in a home environment with more conflict and disorganization exhibited higher ADHD inattentive and hyperactive/impulsive symptoms as reported by their mothers. Home environment also moderated the relation between maternal ADHD symptoms and hyperactivity-impulsivity in 7-year-old boys in that higher hyperactivity-impulsivity symptoms were reported by mothers with ADHD symptoms for boys who lived in homes with frequent conflicts and disorganization (Auerbach et al., 2017).

Despite its strong genetic link, ADHD symptoms tend to be exacerbated or ameliorated by environmental demands or conditions (Kendall & Shelton, 2003). Families with children diagnosed with ADHD express lower levels of satisfaction with their family functioning (Limbers, Ripperger-Suhler, Boutton, Ransom, Warni, 2011; Moen, Hedelin, & Hall-Lord, 2014), which often presents additional family adversity to children with ADHD (Counts, Nigg, Stawicki, Rappley, & von Eye, 2005; Foley, 2011).

For example, families with children diagnosed with ADHD report difficulties with communication, problem solving, conflict resolution, and relationships (Cunningham & Boyle, 2002), more family conflicts and disorganization, (Mulligan et al., 2011), and lower family cohesion (Biederman et al., 1995; Schroeder & Kelley, 2008). Moroney et al. (2017) found that negative parenting practices reported by parents via the Alabama Parenting Questionnaire (APQ, Frick, 1991; Shelton, Frick, & Wootton, 1996) significantly mediated the relation between parent ADHD symptoms and child ADHD symptoms independently of child sex, age, race, and parent depression.

Crea, Chan, and Barth (2013) investigated family coherence and adaptability among the family members rated by adoptive parents of children diagnosed with ADHD and found that foster care predicts higher level of ADHD symptoms but family cohesion acts as a full mediator of this relation. According to Mulligan et al. (2011), being in a home environment with lower support leads to higher hyperactivity, impulsivity and oppositional behaviors in children with ADHD and their unaffected siblings. Parents of children diagnosed with ADHD tend to score higher on parenting stress than parents of children without an ADHD diagnosis (Theule, Wiener, Tannock, & Jenkins, 2013). This parenting stress seems to directly contribute to a lower quality of family functioning (Haydicky, Shecter, Wiener, & Ducharme, 2015) and a higher level of conflicts among family members (Johnston & Mash, 2001). Married and non-married adults with ADHD tend to report more family dysfunction when compared to controls (Eakin et al., 2004; Moen et al., 2014). Moreover, families with children diagnosed with ADHD seem to report lower levels of cohesiveness and family organization regardless of their socioeconomic status (Foley, 2011).

Research suggests that significantly worse general family climate and functioning assessed by the Family Assessment Device (FAD) is reported by parents whose children diagnosed with ADHD are not medicated versus children with ADHD who are on medication (Moen et al., 2014). Adolescents with ADHD and other comorbid externalizing disorders have mothers who report dissatisfaction with life, and both parents are less interested in the activities in which their children engage compared to adolescents with ADHD alone (Hurtig et al., 2007). Given that differences in family functioning may make children more susceptible to ADHD symptoms, particularly in the context of neuropsychological risk, it was a focus of this study.

Respondents for Family Functioning

Importantly, one aim of the current study was to collect information about family functioning directly from children and not their parents, because children's own perceptions of family functioning should play an important role in how family functioning impacts their own behavior and well-being. Also reports on family functioning (which are subjective in nature) likely depend on the perspective of the individual. For example, according to Mandemakers and Dykstra (2008), perceptions of children and parents on mutual assistance or family contact depend on expectations, motivations, or feelings of family members. Parents seem to be strongly motivated by family obligations and personal norms when describing the interactions with their children (Mandemakers & Dykstra, 2008). Also, studies of parents and children show differences in their reported quality of their relationship, support provided to each other, and frequency of contact (Shapiro, 2004). There is some evidence that suggests that with regard to physical complaints, motor functioning and positive emotions as well as internalizing problems, overall emotional functioning and social functioning of the child (Eiser & Morse, 2001), parents should not serve as substitutes for child ratings (Theunissen et al., 1998), because their reports are often not equivalent to that of the child. According to Limbers et al. (2011), the child's perspective should be included in pediatric treatment outcome research, because of the differences in reports of parents and their children. Thus, the current study aimed to consider the child's perspective of family functioning.

Grit and ADHD

According to Duckworth, Peterson, Matthews, and Kelly (2007), grit reflects an ability to persevere so that one can reach future goals over several years or decades and can be differentiated from self-control or the capability to perform actions leading to accomplishing a momentary goal despite the possibility of engaging in more appealing alternatives (Duckworth & Gross, 2014). Grit helps an individual handle overwhelming, exhausting circumstances without giving up (Tough, 2012). Grittier individuals usually work harder with more effort when facing challenges, failure, or adversity—and are successful and attain their goals (Reed, 2014). Grit predicts success even when accounting for IQ and conscientiousness (Duckworth, Peterson, Matthews, & Kelly, 2007).

There are numerous examples in the literature of positive outcomes associated with grit. Grittier children in Chicago public schools were able to graduate as expected (Eskreis-Winkler, Shulman, Beale, & Duckworth, 2014), relative to those with less grit. In one longitudinal study, finalists of the national spelling bee competition who scored higher on grit were willing to practice a significantly longer time, even when the task was less internally rewarding but necessary for success in the competition, and their deliberate practice mediated the relation between grit and the advancement to the next round (Duckworth, Kirby, Tsukayama, Bernstein, & Ericsson, 2011). Higher grit seems to explain young teachers' retention and willingness to teach effectively (Robertson-Kraft & Duckworth, 2014). Police detectives who score higher on grit and mental health professionals who experienced problems comparable to their clients in the past but who score higher on grit are significantly more engaged at their work (Eskreis-Winkler, Shulman, & Duckworth, 2014). Adults who are more educated as measured by the degree completed tend to score higher on grit (Duckworth et al., 2007). Results in the Duckworth et al. study provide evidence that higher grit scores are associated with higher GPAs even when accounting for SAT scores. It also appears that in a sample of undergraduate students, those with lower IQ scores were grittier and may have been more determined to work harder (Duckworth et al., 2007). Among West Point cadets, grittier students were more likely to complete the challenging summer program which is known for its demands on physical, mental, and emotional capacities (Duckworth & Quinn, 2009). Lastly, grittier individuals diagnosed with HIV report higher independence in daily life compared to individuals with HIV who score lower on grit measure (Moore et al., 2018).

Grit also appears to be negatively related to inattention (Ralph, Wammes, Barr, & Smilek, 2017). Specifically, these authors found that inattention in a sample of undergraduate students, expressed as spontaneous brief everyday mind wandering, was negatively correlated with grit even when accounting for consciousness. The results also suggest that students who scored lower on grit experience more absentmindedness, lower ability to purposefully focus their attention among various tasks, higher distractibility, and more everyday mistakes due to their inattention (Ralph et al., 2017).

Despite these many examples of grit relating to positive outcomes, no known studies have investigated grit as a construct among individuals with ADHD. Given that individual difference factors may play a role in whether ADHD symptoms manifest in the face of neuropsychological risk and given that grit is associated with positive outcomes, sometimes in the context of adversity, the current study aimed to fill this gap in the literature by examining the construct of grit. Specifically, grit was examined in terms of its direct relation to ADHD symptoms and as a moderator in the relation between other risk factors and ADHD symptoms.

Current Study and Hypotheses

Rationale

Despite high genetic vulnerability for developing ADHD, this disorder is likely expressed under various environmental conditions, thus leading to a heterogeneous presentation of its symptoms (Doyle, Willcutt et al., 2005). Endophenotypes underlie genetic risk for phenotypical outcome. Endophenotypes are considered to be less genetically complex because of their position in the pathways from genes to behavior (McAuley et al., 2014) and are found in children diagnosed with ADHD and their relatives regardless of the ADHD symptoms (Rommelse et al., 2007). More specifically, some children who show genetic vulnerability for ADHD and demonstrate endophenotypes (e.g., via computer tasks) are diagnosed with ADHD, whereas other children who share those same risks are not diagnosed.

The current study aimed to explore this conundrum and provide knowledge with regard to children who are at risk for developing ADHD. Based on the reviewed literature, the focus of the current study was to examine the possible influence of family functioning and child grit on the expression of endophenotypes as ADHD symptoms. The rationale for the study was that environmental and personal characteristics may make a difference in turning the genetic vulnerability into the mental disorder. Understanding those possible moderators is important to inform possible prevention efforts.

The study also aimed to enrich the literature base by examining neuropsychological endophenotypes specific to ADHD behavioral symptoms, an area of research that is still in its infancy. Moreover, grit as a construct has not been investigated in the ADHD population, and it is important to consider it as a possible protective moderator in the relation between ADHD endophenotypes and ADHD symptoms.

The current study used a community sample. Sampling from a general population was supported by a study by Crosbie et al. (2013) that investigated the relation between ADHD endophenotypes (e.g., response disinhibition, RT, RT variability) and ADHD symptoms in a community sample of 16,099 children and adolescents between the ages of 6 and 18. Their results suggest that children with higher parent-rated ADHD symptoms demonstrated higher disinhibition, longer RTs and greater RT variability.

Rommelse, Altink, Martin et al. (2008) explored whether the relation between endophenotypes and ADHD symptoms is moderated by age and found that older nonaffected siblings performed more similar to controls than younger nonaffected siblings. Likewise, Uebel et al. (2010) found that RT variability was more pronounced in younger children diagnosed with ADHD. Therefore, age of the child was considered as a potential covariate in the current study. Given that the prevalence rates of ADHD are higher among males than females (APA, 2013), gender of the child also was considered as a potential covariate. Child race and child IQ were also considered as potential covariates. Child IQ was considered because several studies reported significantly lower IQ for the children diagnosed with ADHD compared to controls (Frazier, Demaree, & Youngstrom, 2004, van Ewijk et al., 2014) or compared to siblings without ADHD symptoms (Oerlemans et al., (2015). A study by Rommelse et al. (2008) also found that child IQ partially mediated the relation between endophenotype composite and ADHD symptoms. Race was included as a covariate because several studies found that teacher reports of ADHD symptoms vary with regard to the child's race, in that African American children are rated as more inattentive, as well as hyperactive/impulsive, by their teachers compared to white children (Lawson, Nissley-Tsiopinis, Nahmias, McConaughy, & Eiraldi, 2017). Moreover, African American children tend to exhibit more ADHD symptoms, but are diagnosed less often when compared to white children (Miller, Nigg, & Miller, 2009).

Hypotheses

Because of the established link between endophenotypes and ADHD symptoms, it was expected that endophenotypes would be moderately related to ADHD symptom domains (i.e., inattention, hyperactivity/impulsivity) based on parent- and teacher-report (Hypothesis 1). Specifically, response disinhibition and RT variability were expected to be positively related to ADHD symptoms, whereas working memory was expected to be negatively related to ADHD symptoms (i.e., because working memory *deficits* would relate to more ADHD symptoms). Based on prior research, it also was hypothesized that children coming from a family characterized by higher levels of family dysfunction would exhibit higher levels of ADHD symptoms (i.e., positive correlation; Hypothesis 2). It was expected that grittier children (i.e., who receive a higher score on the questionnaire assessing their ability to pursue long-term goals despite obstacles) would exhibit lower levels of ADHD symptoms (i.e., negative correlation; Hypothesis 3). It was expected that family dysfunction would moderate the relation between endophenotypes and ADHD symptoms by exacerbating it, such that children coming from families with higher levels of family dysfunction and who show neuropsychological endophenotypic deficits would exhibit higher levels of ADHD symptoms than children coming from a healthier family environment and who have those deficits (Hypothesis 4). It was hypothesized that child grit would moderate the relation between endophenotypes and ADHD symptoms by attenuating it, meaning that grittier children showing neuropsychological endophenotypic deficits would exhibit lower levels of ADHD symptoms than less gritty children with those deficits (Hypothesis 5). It also was expected that child grit would moderate the relation between family dysfunction and ADHD symptoms by attenuating it, meaning that grittier children who come from families with higher levels of family dysfunction would exhibit lower levels of ADHD symptoms than less gritty children with family dysfunction (Hypothesis 6). Finally, it also was hypothesized that the magnitude of the effect of endophenotypes on ADHD symptoms in families with higher levels of family dysfunction would be smaller for children with higher levels of grit. Child grit was expected to play a protective role and minimize ADHD symptoms despite the presence of endophenotype risk and high levels of family dysfunction (Hypothesis 7).

CHAPTER II – METHOD

Participants

Following IRB approval, a community sample was recruited that included 84 children ages 11 to 17 years, with normal or corrected to normal vision and hearing, and their parents and teachers. See the Procedure section for recruitment details. An *a priori* power analysis advised to gather a sample size of N = 81 participants for an effect size of f^2 = .10 (considered small to medium; Cohen, 1992), α < .05, power of .80 for the most complex model being tested, with 10 overall predictors [3 control variables (estimated), 3 main effects, 3 two-way interactions, and 1 three-way interaction], with the three-way interaction being the tested predictor. Thus, this sample size was considered appropriate for all analyses examining parent-rated ADHD as the criterion. All tests of hypotheses considering teacher data were analyzed on a subsample of N = 40, given that teachers of 40 children responded to questionnaires. Thus, the analyses examining teacher-rated ADHD symptoms of children were possibly underpowered.

Exclusion criteria included use of non-stimulant medications to treat ADHD (due to their long half-life), failure to learn or understand the computer tasks, parent-reported diagnosis of intellectual disorder, parent-reported diagnosis of low-functioning/nonverbal autism spectrum disorder; schizophrenia spectrum and other psychotic disorders, and earning an IQ score on the Kaufman Brief Intelligence Test, Second Edition of less than 70. No participants were excluded based on these criteria, in part due to screening procedures at the time of scheduling (see Procedure section). Participants taking stimulant medications (i.e., with a short half-life) were asked not to take it on the day of testing. Parents reported an ADHD diagnosis for 14 children, comorbid diagnoses of

ADHD and learning disability (LD) for 6 children, and a LD diagnosis for 3 children. Other diagnoses were as follows: depression (n = 5), anxiety (n = 11), panic (n = 5), mania (n = 3), conduct disorder (n = 2), oppositional defiant disorder (n = 5), substance use (n = 1), suicide attempt (n = 2). Sample characteristics are shown in Table 1.

Rating Scale Measures

For each of the following rating scale measures, internal consistency for the current study (Cronbach's alphas) are displayed in Tables 2 (full sample) and 3 (subsample).

Vanderbilt ADHD Diagnostic Rating Scale

The Vanderbilt ADHD Diagnostic Parent Rating Scale (VADPRS; Wolraich et al., 2003) is a 45-item scale that assesses ADHD symptoms, oppositional/defiant/conduct problem behaviors, and anxiety and depression symptoms on a 4-point Likert format from 0 = *never* to 3 = *very often* (Bard, Wolraich, Neas, Doffing, & Beck, 2013). Parents also rated their child's academic performance and behavior in the classroom on a 5-point scale from 0 = *problematic* to 5 = *above average*. Higher scores mean greater problem behaviors or symptoms.

Construct validity was evaluated by performing factor analysis, which supported a 4-factor solution (inattention, hyperactivity/impulsivity, conduct/oppositional, and anxiety/depression). The computed alphas ranged from .91 to .94, indicating appropriate internal consistency (Bard et al., 2013). Test-retest reliability for inattention and hyperactivity/impulsivity scales completed by parents of high-risk children with ADHD were .91 and .92, respectively. Concurrent validity was assessed by comparing the scores from the VADPRS with the Diagnostic Interview Schedule for Children-IV, Parent

Version (DISC-IV-P) obtained during the interview and yielded correlations of .69 for inattention and .66 for hyperactivity/impulsivity scales.

The Vanderbilt ADHD Diagnostic Teacher Rating Scale (VADTRS) is a 35-item scale that assesses ADHD symptoms, oppositional/defiant/conduct problem behaviors, and anxiety/depression symptoms and includes responses on a 4-point Likert format from 0 = *never* to 3 = *very often* (Wolraich, Bard, Neas, Doffing, & Beck, 2013). Teachers also rated children's academic and behavioral performance in the classroom including reading, mathematics, written expression, peer relations, following directions, disrupting class, assignment completion, and organizational skills on a 5-point scale from 0 = *problematic* to 5 = *above average*. Exploratory factor analysis confirmed the hypothesized 4-factor solution (inattention, hyperactivity/impulsivity, conduct/oppositional, and anxiety/depression), thus providing evidence for construct validity. The alpha coefficients for all scales ranged from .89 to .96, suggesting good internal consistency (Wolraich et al., 2013). The correlation between the Strengths and Difficulties Questionnaire (SDQ) and VADTRS scales of inattention and hyperactivity/impulsivity were both .81, indicating strong convergent validity.

For the current study, the inattention and hyperactivity/impulsivity scales were of interest and were investigated separately in the analyses as specific domains of ADHD. A study by Narad et al. (2015) reported support for a two-factor model of ADHD in the school and home environments. That is, a two-factor structure of ADHD symptoms fits well for both parent- and teacher-reported symptoms of ADHD. Their study also shed light into differences in parent- and teacher reports of ADHD symptoms across the inattention and hyperactivity/impulsivity domains. More specifically, their study found that parents endorsed more severe symptoms of ADHD for their children than the teachers. Their findings also suggest that the link between parents' and teacher's reports for the hyperactivity/impulsivity domain is higher than for the inattention domain; possibly due to being more noticeable compared to inattentive symptoms, hyperactivity/impulsivity symptoms to be more talked about between parents and teachers (Narad et al., 2015), and possibly because the symptoms of inattention are more likely to be profound in the classroom environment where distractibility matters more compared to home (Narad et al., 2015). Doyle, Faraone et al. (2005) suggest exploring qualitative and quantitative cognitive and executive functioning differences between ADHD inattentive and ADHD hyperactive/impulsive dimensions to illuminate whether the endophenotypic deficits are general or applicable to specific ADHD domains. Therefore, the analyses were run separately for parent and teacher reports as well as separately for inattention and hyperactivity/impulsivity domains. The parent-rated inattention items and hyperactivity/impulsivity items were summed from the VADPRS to obtain a parent-rated inattention domain score and a parent-rated hyperactivity/impulsivity domain score, respectively. Similarly, the teacher-rated inattention items and hyperactivity/impulsivity items were summed from the VADTRS to obtain a teacher-rated inattention domain score and a teacher-rated hyperactivity/impulsivity domain score, respectively.

The General Functioning Subscale of the McMaster Family Assessment Device

The General Functioning Subscale (GFS; Epstein, Baldwin, & Bishop, 1983) measure was completed by children to assess the general functioning of the family (Epstein et al., 1983). The GFS is a 12-item measure and represents a subscale on the

Family Assessment Device (FAD). The FAD includes 60 statements about how families solve problems, communicate, express emotions, divide roles, or follow rules of the household. The FAD consists of seven subscales: problem solving, communication, roles, affective responsiveness, affective involvement, behavior control, and general functioning (Young et al., 2013). Higher scores suggest unhealthy family functioning (i.e., family dysfunction).

The FAD has been used in previous studies with families with a child with ADHD (Moen, Hedelin, & Hall-Lord, 2014), and its psychometric properties have been also established (Byles, Byrne, Boyle, & Offord, 1988; Kabacoff, Miller, Bishop, Epstein, & Keitner, 1990). The FAD was developed based on the responses of 503 individuals including 112 families (Epstein et al., 1983). Cronbach's alphas ranging from .83 to .86 for the general functioning subscale, and from .57 to .80 for other subscales were reported for nonclinical, psychiatric, and medical samples (Kabacoff et al., 1990). The FAD's validity has been established via several studies. The FAD seems to differentiate between families with clinical problems and families that do not report clinically significant disorders, and FAD mean scores were significantly higher for the clinically presenting families (Epstein et al., 1983). More recently, significant correlations have been found between FAD scores and ratings from semi-structured interviews conducted by clinicians (Barney & Max, 2004). Moreover, according to Epstein et al. (1983), the FAD seems to predict 28% of the variance in married couples' marital satisfaction scores reported on the Locke Wallace Marital Satisfaction Scale (Locke & Wallace, 1959).

For the current study, family dysfunction was assessed by the general functioning subscale (GFS) raw score of the FAD, which indicates overall family functioning and has been used to study families of children diagnosed with ADHD (Foley, 2011). Children rated the statements on the GFS by choosing one of 4 possible responses: 1 = *strongly agree*, 2 = *agree*, 3 = *disagree*, or 4 = *strongly disagree*, based on how well they think the statement describes their family (Foley, 2010). Negatively phrased items were reverse-scored. A higher score reflects poorer family functioning (i.e., higher family dysfunction). After reverse scoring, all of the responses from items on the GFS were added to compute the raw score (Kaplan, Crawford, Fisher, & Dewey, 1998).

For psychometrics specifically focused on the GFS, one study that used the general functioning subscale (GFS) measure to assess family dysfunction within an ADHD sample reported a Cronbach alpha of .93, suggesting high internal consistency (Foley, 2011). Kabacof et al. (1990) also validated the GFS as a single measure of family functioning that also highly correlated with the principal component of the items comprising the six subscales among various populations (r = .85 in nonclinical; r = .87 in psychiatric; and r =.88 in medical).

Because the GSF assesses affect, communication, cohesiveness, and problem-solving in the family, there is a risk that biases may increase the parents' desire to be seen in a more positive light with regard to the family environment that they are providing or maintaining for their children (as discussed earlier). Thus, the current study focused specifically on the child's perspective. The readability of the subscale was assessed by Flesch-Kincaid readability index (MS Word 2010). The Flesch reading ease score was 61 out of 100, and the Flesch-Kincaid Grade Level was 7.0. This finding suggests that children of 11 years of age can be administered the GFS. The GFS has been previously used in ADHD research and in a study where children as young as age 7 years responded to statements about family functioning (Epstein et al., 1983; Foley, 2011).

Short Grit Scale

Grit can be defined as a long-term passion, perseverance, and stamina for reaching future goals despite adversity, obstacles and failure (Duckworth et al., 2007). It is considered to be a personal trait (Duckworth & Quinn, 2009) and involves effort and interest in projects that can take several months or years to complete (Duckworth et al., 2007). The Short Grit Scale (Grit-S; Duckworth & Quinn, 2009) includes 8 items for which children rated the positive and negative statements by choosing one of the following options: *very much like me, mostly like me, somewhat like me*, *not much like me*, *not like me at all.* The positive statements were reverse coded. The average grit score was calculated by averaging the item scores. The higher score represents a grittier person. According to Duckworth and Quinn (2009), the Grit-S scale has been validated on cadets of West Point as well as samples of adolescents, adults, college students, and children. The factor analysis in their study showed a 2-factor structure with Consistency of Interest and Perseverance of Effort. The reported correlation between these two factors was significant with $r = .59$. The scale showed good internal consistency with Cronbach alphas ranging from .73 to .83 (Duckworth & Quinn, 2009).

The total Grit-S scale score is often used in research. Prior research has shown its importance in predicting academic achievement (Bowman, Hill, Denson, & Bronkema, 2015) and spelling performance in children (Duckworth, Kirby, Tsukayama, Berstein, & Ericsson, 2010). The Grit-S scale correlated significantly with the conscientiousness personality trait from the Big 5, $r = .77$. It also was positively associated with education achievement and inversely related to the number of changes an individual makes in his lifetime even when accounting for the variance contributed by conscientiousness, thus demonstrating its predictive validity. The Grit-S scale also was stable over time, given that its scores one year apart were strongly and significantly correlated, $r = .68$, suggesting good test-retest reliability (Duckworth & Quinn, 2009).

Because this scale was also completed by children, the readability of the subscale was assessed by Flesch-Kincaid readability index (MS Word 2010). The Flesch reading ease score was 63 out of 100, and the Flesch-Kincaid Grade Level was 6.5. This suggested that children as young as 11 years of age could be administered the Grit-S.

Demographic and Diagnostic Form

Parents completed a demographic questionnaire for their own and their children's information. Parents provided name, date of birth, gender, race, and ethnicity. Parents reported on their family income, education, and employment. Parents also provided information about the number of people living in the household, number of siblings, number of parents at home, the quality of the relationships between siblings and the child as well as between parents and the child on the scale of 0 = *poor*, 1 = *fair*, 2 = *good* and 3 = *excellent* (K-SADS-PL, Kaufman et al., 1997). Academic information was obtained about the child including his/her education level, current grades, repeated grades, current school setting, specialized services received by the child, academic subject strengths and weaknesses, number of detentions, suspensions and expulsions, as well as reasons for disciplinary actions. Parents reported on their child's current medication and dosage, lifetime treatment history, diagnoses, prenatal and postnatal history, developmental history including milestones, allergies, hospitalizations, serious injuries, head injuries including loss of consciousness, current or past significant medical health problems, and academic history including grades, best and worst subject, disciplinary actions, specialized services, and peer relations. Teachers received a brief demographic form including name of the child, grade, and special education services status.

Neuropsychological Measures to Assess ADHD Endophenotypes

The Go/No-Go Task

The Go/No-Go Task (Fillmore, Rush, & Hays, 2006) was administered via Inquisit 4 Lab (Inquisit, 2014) and measured motor response disinhibition and RT variability (ADHD endophenotypes). On each trial, first a small black cross was presented on the screen, and then a white rectangle appeared on the computer screen. This rectangle turned either blue or green. Participants were instructed to press a spacebar as quickly as possible with their preferred index finger whenever the rectangle turns green. They were asked not to respond to the blue triangle. No practice was given, and it lasted about 10 minutes.

To measure response disinhibition, the number of commission errors across all 125 no-go trials (child responded when they should not have responded) was computed (O'Brien, Dowell, Mostofsky, Denckla, & Mahone, 2010). More specifically, errors were identified via sorting the error column for the repeated trials from each child's Inquisit output file and summing errors on no-go trials across each child's data block, providing an aggregate commission error variable per child for the participant-level data set. Prior studies found that children diagnosed with ADHD produce more errors of commission in comparison to controls (O'Brien et al., 2010; Vodka et al., 2007). Commission errors have been associated with both inattention and hyperactivity/impulsivity dimensions among children with ADHD (Brocki, Tillman, & Bohlin, 2010).

To measure intraindividual RT variability, the errors on 125 go trials (when the child did not respond but was supposed to) were identified and eliminated from the Inquisit output file containing the child's repeated trials. The latencies on correct go trials in the Inquisit output file represented the child's RTs. The latencies (RTs) on correct go trials were used to compute the standard deviation (SD) of the latencies (RTs), providing an aggregate RT variability variable per child for the participant-level data set. More specifically, RT variability was expressed as a standard deviation of child's RTs (latencies) on correct go trials.

The Digit Span Task

The Digit Span Task (Conway et al., 2005) assessed auditory working memory. In the past, studies have used the Digit Span task from the Wechsler Intelligence Scale for Children (WISC-III, Wechsler, 1991; Rommelse, Altink, Martin et al., 2008). Some studies show that ADHD samples scored significantly lower only on the backward digit span (Karatekin & Asarnow, 1998; O'Brien et al., 2010). However, some research on endophenotypes suggests both ADHD probands and their unaffected siblings demonstrate significant impairment on both verbal digit span forward and backward tasks (Rommelse, Altink, Martin et al., 2008); therefore, in the current study, both measures were used (separately) to reflect participants' working memory. Participants completed the auditory digit span forward and backward tasks via Inquisit 4 Lab (Inquisit, 2014). At first, they saw a red circle on the screen. Then the red circle disappeared from the screen, and they heard a sequence of digits from 1 to 9. Another red circle signaled the end of the digit sequence. Participants then saw a textbox presented in the middle of the screen where they typed the digit sequence they have heard. They either typed the sequence exactly as they heard it (digit span forward) or in the reversed order it was presented (digit span backward). Participants were able to practice both tasks before the assessment. The maximum number of digits recalled correctly before making two consecutive errors was measured on both tasks and served as the respective score for each task (Gau & Shang, 2010; Inquisit, 2014; Rommelse, Altink, Martin et al., 2008). The Inquisit output file offered a summary for each participant with the digit span forward and digit span backward performance scores. This measure is comparable to the traditional assessment of digit span forward and backward (Inquisit, 2014).

Child IQ Measure

Kaufman Brief Intelligence Test, Second Edition

Kaufman Brief Intelligence Test, Second Edition (K-BIT-2; Kaufman & Kaufman, 2004) is a brief test for assessment of intellectual functioning, which has also been recommended for evaluation of intelligence in individuals with ADHD, because it is not so time-consuming (Kaufman & Kaufman, 2001). According to Kaufman and Kaufman (2004), the standardization of K-BIT-2 was conducted with individuals between 4 and 90 years old. This test consists of three subtests including Verbal Knowledge and Riddles (verbal tasks) as well as Matrices (nonverbal task). It generates a verbal, nonverbal, and overall IQ composite. Verbal tasks assess crystalized intelligence and individuals' verbal reasoning, verbal concept formation, and range of general information. The nonverbal task measures fluid intelligence and the ability to solve problems visually by perceiving relationships and similarities.

The K-BIT-2 standardization sample consisted of 2,120 individuals between 4 and 90 years old. Both genders were represented. The Cronbach's alpha for the three subtests ranged from .86 to .96 suggesting good internal consistency. Test-retest reliability of .91 was reported for the verbal subtests, .88 for the nonverbal subtest, and .90 for the overall IQ composite. The K-BIT's construct validity was demonstrated by high correlations with the Wechsler Abbreviated Scale of Intelligence (r = .90), Wechsler Intelligence Scale for Children, Third Edition (r = .76), and Wechsler Intelligence Scale for Children, Fourth Edition (r = .77).

For the current study, the K-BIT-2 was used to assess children's intelligence. Given the neurocognitive focus of the constructs of interest, it was important to consider the findings in light of the children's overall level of intelligence. In addition to being used for descriptive purposes, the K-BIT Composite IQ was specifically examined as a potential covariate in the current study.

Procedure

Recruitment

Data collection was conducted in Mississippi and received Institutional Review Board (IRB) approval at The University of Southern Mississippi (USM), prior to recruitment. Participants were recruited from college students in the psychology subject pool at USM who are parents, as well as other school, community, and clinic referral sources in Mississippi, parent verbal referral, and via the distribution of public fliers. Parents of potential participants with ADHD were contacted via listservs and social media platforms, particularly Facebook. At the time of scheduling, parents of children were reminded to withhold the child's ADHD medication (if applicable) on the day of testing. Before testing commenced, the research assistant asked the parent to confirm that the child was not diagnosed with ASD or intellectual disability.

Data Collection

Most parents and children participated in person, in a laboratory at USM. Field data collection (i.e., at a library and Sunday-school center) was used as well because these sites were closer to interested participants. For field data collection, consent and measure completion from the parent could be provided solely online or via paper-and-pencil, hard copy consent and measures (i.e., rather than meeting the researcher in person), if preferred. Teachers had the option to be mailed hard copies of the consent and measures to complete and return in a prepaid envelope, if they had no means of completing the surveys electronically. One teacher requested this option but did not return the hard copy measures that were mailed. Data collection with the child was only initiated following parental consent. Given the direct testing involved, data collection with children was face-to-face, following parent consent and child assent.

After providing consent, parents completed the Vanderbilt ADHD Diagnostic Parent Rating Scale and the Demographic and Diagnostic Form online via Qualtrics, an online survey platform (Qualtrics, 2014). For field data collection, the parent had the option (not used) to fill out paper and pencil measures (and return in a prepaid envelope) if the parent had no means of completing the surveys electronically. After parents consented to involve teachers' ratings, parents were asked to provide the email address for the child's teacher. Teachers were sent a Qualtrics link with a consent form to participate in the study. After teachers' consent, they were redirected to complete the Vanderbilt ADHD Diagnostic Teacher Rating Scale and to provide information regarding the child’s demographics and basic academic information. Following the clinical recommendations of the American Academy of Child and Adolescent Psychiatry (2007) and American Academy of Pediatrics (2011), data about ADHD symptoms were gathered from both parents and teachers. Collecting ratings of child behaviors from parents and teachers also was in line with DSM-5 criteria (DSM-5; APA, 2013) that require the symptoms of ADHD to be identified and rated by various informants in different surroundings (e.g., home, school). After their parents provided consent and after the children provided assent, children were administered the K-BIT-2. The children then completed the Go/No-Go task and the Digit Span task as neuropsychological measures. After the computer tasks, children responded to the Grit-S scale and The General Functioning Subscale (GFS) of the McMaster Family Assessment Device also administered through Qualtrics.

Testing with the children lasted approximately 2 hours. Parent measures were completed in no more than 30 minutes, whereas teacher measures took approximately 15 minutes. Children, parents, and teachers were informed that they could withdraw from the study at any time without penalty. Children received a gift card of $20 as an incentive for their time and participation in the study. Teachers were entered into a drawing for a $20 gift card, which was communicated to them during the consent procedures. One teacher was identified in the drawing and contacted about the preference of the gift card delivery.

CHAPTER III - RESULTS

Coding of Variables

Participants were assigned an ID number. After data were collected for each participant from all sources (parent Qualtrics, teacher Qualtrics, child Qualtrics, and child direct testing), they were merged in SPSS (all data sources matched by the ID number) to create a de-identified single database. All variables of interest for the current study were measured on a continuum.

Preliminary Analyses

The dataset was checked for any data entry mistakes, missing data, unreasonable values, or outliers by creating frequency tables. Data entry errors were minimal and were corrected at this stage. The dataset had no missing values; therefore, no imputation was needed. Descriptive statistics for variables of interest are displayed in Table 2 for the full sample of $N = 84$ and in Table 3 for the subsample of $N = 40$. Variables were checked for skewness and kurtosis. Distribution of the response disinhibition variable showed high skewness (2.42) and kurtosis (7.07). One extreme outlier (i.e., greater than four standard deviations from the sample mean) was winsorized, meaning that the outlier was replaced with the next highest score, keeping rank order. The winsorized distribution of the response disinhibition variable showed acceptable skewness of 1.88 and kurtosis of 3.21, as shown in Table 2.

Intercorrelations (via bivariate correlation analyses) for variables of interest were conducted for the full sample of $N = 84$ (Table 4) and the subsample of $N = 40$ (Table 5). Analyses performed on the full sample of $N = 84$ showed that response disinhibition was positively correlated with RT variability, parent-rated hyperactivity/impulsivity, and teacher-rated inattention. Furthermore, RT variability was negatively related to both indices of working memory (DSF, DSB) and to child grit. RT variability was also positively correlated with parent- and teacher-rated hyperactivity/impulsivity as well as teacher-rated inattention. Both measures of working memory (DSF and DSB) were positively associated with each other and each were negatively associated with teacher-rated inattention. Family dysfunction was negatively correlated with child grit and positively correlated with teacher-rated inattention and teacher-rated hyperactivity/impulsivity. Parent-rated inattention was positively related to parent-rated hyperactivity/impulsivity, and teacher-rated inattention was positively related to teacher-rated hyperactivity/impulsivity.

Analyses of the intercorrelations in the subsample of *N* = 40 followed the same general pattern with some exceptions. Specifically, response disinhibition was significantly negatively correlated with working memory (DSB), whereas its relation with parent-rated hyperactivity/impulsivity was no longer significant. RT variability was positively correlated with family dysfunction but only marginally negatively correlated with child grit and not significantly correlated with parent-rated hyperactivity/impulsivity. Working memory (DSF) became positively associated to child grit and negatively associated to parent-rated inattention. Both measures of working memory (DSF and DSB) were only marginally positively correlated with each other. Working memory (DSB) was negatively correlated with teacher-rated hyperactivity/impulsivity. Further, the relations between child grit and parent-rated ADHD domains were no longer significant.

Next, zero-order correlations were conducted between the four demographic variables (child age, gender, race, and IQ) and parent- and teacher-rated inattention and hyperactivity/impulsivity (Table 6) to determine if the child variables should be covaried in subsequent analyses examining each of these respective criterion variables.

All demographic variables were continuous or dichotomized (i.e., dummy coded) before performing correlational analyses. Child IQ was significantly negatively related to parent-rated hyperactivity/impulsivity, $r = -.226$, $p = .039$, meaning that children with lower IQ scores were likely to be rated by their parents as more hyperactive/impulsive. Child gender (coded 0 = male, 1 = female) was significantly negatively related to teacher-rated inattention, $r = -.315$, $p = .048$, with teachers likely endorsing higher inattention symptoms for boys. Following these results, child IQ was included as a covariate in statistical analyses where parent-rated hyperactivity/impulsivity was a criterion variable, and child gender was considered as a covariate in statistical analyses where teacher-rated inattention was a criterion variable.

Hypothesis Testing: Correlation Analyses

Bivariate (or partial) correlation analyses were used to test Hypotheses 1 through 3. For all subsequent analyses used to test the hypotheses, child IQ was included as a covariate in analyses where parent-rated hyperactivity/impulsivity was the criterion variable, and child gender was included as a covariate in analyses where teacher-rated inattention was the criterion variable. Thus, partial correlations were used for these specific criterion variables. Marginal findings (identified by a p value less than .10) were also reported because only 40 teachers of child participants responded to the questionnaires. It is possible that the subsample with teacher data ($N = 40$) was underpowered due to a lower sample size, and thus, the ability to detect significant effects was likely limited. The reported marginal findings should be interpreted with caution.

Hypothesis 1

To test Hypothesis 1, 16 bivariate or partial correlation (if covariates were included) analyses were conducted to investigate the link between the four endophenotypes [response disinhibition, RT variability, and working memory (DSF, DSB)] and parent-rated inattention, parent-rated hyperactivity/impulsivity, teacher-rated inattention, and teacher-rated hyperactivity/impulsivity. Results are presented in Table 7 and indicate that response disinhibition was positively correlated with parent-rated hyperactivity/impulsivity, RT variability was positively related to teacher-rated inattention and teacher-rated hyperactivity/impulsivity, and both measures of working memory (DSF and DSB) were negatively related to teacher-rated inattention. These results indicate that children with higher response disinhibition were likely rated by parents as more hyperactive/impulsive and that children demonstrating more variable RTs were rated as more inattentive and hyperactive/impulsive by their teachers. The findings also show that children with better working memory abilities experiences lower inattention problems as rated by teachers.

Hypothesis 2

To test Hypothesis 2, two bivariate correlation analyses and two partial correlation analyses to account for covariates as indicated were conducted to determine the association between family dysfunction and the parent- and teacher-rated ADHD domains. Results are presented in Table 8. Family dysfunction was positively associated with teacher-rated inattention and teacher-rated hyperactivity/impulsivity, meaning that children who live in a family with poorer functioning were likely to be rated by teachers as more inattentive and hyperactive/impulsive.

Hypothesis 3

To test Hypothesis 3, two bivariate correlation analyses and two partial correlation analyses to account for covariates as indicated were conducted to determine the association between child grit and the parent- and teacher-rated ADHD domains. Results are presented in Table 9. Child grit was negatively correlated with parent-rated inattention and parent-rated hyperactivity/impulsivity, suggesting that grittier children were rated as less inattentive and hyperactive/impulsive by their parents.

Hypothesis Testing: Moderated Multiple Regression Analyses

Hypotheses 4 through 7 were tested using moderated multiple regression analyses. Again, child IQ was included as a covariate in analyses where parent-rated hyperactivity/impulsivity was the criterion variable, and child gender was included as a covariate in analyses where teacher-rated inattention was the criterion variable. Because covariates were used when indicated, the control step was significant for all analyses. Main effects for variables of interest were interpreted on the main effects step, accounting for other main effects and the relevant covariate (if applicable). Interactions were interpreted on the relevant interaction step, accounting for main effects and the relevant covariate (if applicable). Again, marginal findings are noted but should be interpreted cautiously. To better understand the nature of the variables, marginal interactions also were plotted.

Hypothesis 4

To test Hypothesis 4, a total of 16 moderated multiple regression analyses (a set of four analyses for each of the four endophenotypes as a predictor) were conducted to examine the moderating effect of family dysfunction on the relation between the four endophenotypes (each examined separately) and the ADHD domains. PROCESS (Hayes, 2013) for SPSS, model 1 was used, which automatically centered the variables and calculated interaction terms. Covariates were used as indicated. Results are presented in Tables 10 through 13.

Response Disinhibition as the Predictor

The first set of four moderated multiple regression analyses examined family dysfunction as a moderator of the relation between response disinhibition and the ADHD domains (Table 10). When considering parent-rated inattention as the criterion variable, the interaction between response disinhibition and family dysfunction was significant, $\Delta F(1, 80) = 4.26$, $p = .04$, and accounted for a significant increase of the variance (5%). The significant interaction was examined through a post-hoc plot (Figure 1). Children with greater response disinhibition were rated as more inattentive by their parents if their families were more dysfunctional compared to children with the same endophenotypic risk who lived in families with less family dysfunction. In contrast, children with less response disinhibition were rated more similarly by parents in terms of inattentive symptoms regardless of the level of family dysfunction.

When parent-rated hyperactivity/impulsivity was examined as the criterion variable, the main effects model was marginally significant, $\Delta F(2, 80) = 2.92$, $p = .06$, due to the effect of response disinhibition. There also was a marginally significant interaction between response disinhibition and family dysfunction, $\Delta F(1, 79) = 3.45$, $p =$

.067, accounting for 4% of additional variance in parent-rated hyperactivity/impulsivity. A reduced model *post-hoc* plot (Holmbeck, 2002; Figure 2) showed that children with higher response disinhibition were rated by their parents as more hyperactive/impulsive if they also lived in more dysfunctional families relative to children with higher response disinhibition who lived in families with low dysfunction. Low family dysfunction did not differentiate between children with and without endophenotypic risk; these children were rated by the parents as similarly hyperactive/impulsive.

When teacher-rated inattention was examined as the criterion variable, the main effects model was significant, $\Delta F(2, 36) = 3.98$, $p = .027$, explaining an additional 16% of the variance. Although family dysfunction explained unique variance, it did not moderate the relation between response disinhibition and teacher-rated inattention.None of the models were significant and none of the variables significantly predicted variance in teacher-rated hyperactivity/impulsivity. Family dysfunction did not moderate the relation between response disinhibition and teacher-rated hyperactivity/impulsivity.

RT Variability as the Predictor

The second set of four moderated multiple regression analyses examined family dysfunction as a moderator of the relation between RT variability and the ADHD domains (Table 11). When parent-rated inattention was considered as the criterion variable, the main effects and interaction models were not significant and none of the variables significantly predicted variance. Family dysfunction did not moderate the relation between RT variability and parent-rated inattention.

When parent-rated hyperactivity/impulsivity was examined as the criterion variable, the main effects model was marginally significant, $\Delta F(2, 80) = 2.38$, $p = .099$, and predicted an additional 5% of the variance (only RT variability, not family dysfunction, was marginally significant). The interaction between family dysfunction and RT variability did not explain significantly more variance in parent-rated hyperactivity/impulsivity.

When teacher-rated inattention was examined as the criterion variable, the main effects model was significant, $\Delta F(2, 36) = 4.17$, $p = .024$, explaining an additional 17% of the variance (only RT variability, not family dysfunction, was marginally significant).. Family dysfunction did not moderate the relation between RT variability and teacher-rated inattention.

When teacher-rated hyperactivity/impulsivity was examined as the criterion variable, the main effects model was significant, $\Delta F(2, 37) = 4.92$, $p = .013$, explaining 21% of the variance (only RT variability, not family dysfunction, was significant). The interaction between family dysfunction and RT variability did not explain significantly more variance in teacher-rated hyperactivity/impulsivity.

Working Memory (DSF) as the Predictor

The third set of four moderated multiple regression analyses examined family dysfunction as a moderator of the relation between working memory (DSF) and the ADHD domains (Table 12). The results indicated that family dysfunction did not moderate the relation between working memory (DSF) and parent-rated inattention, parent-rated hyperactivity/impulsivity, or teacher-rated hyperactivity/impulsivity. Likewise, none of the main effects were significant for these criterion variables.

However, when teacher-rated inattention was considered as the criterion variable, the main effects model was significant, $\Delta F(2, 36) = 4.45$, $p = .019$, explaining an additional 18% of the variance. Both working memory (DSF) and family dysfunction were marginally significant in the main effects model. However, family dysfunction did not moderate the relation between working memory (DSF) and teacher-rated inattention.

Working Memory (DSB) as the Predictor

The fourth set of four moderated multiple regression analyses examined family dysfunction as a moderator of the relation between working memory (DSB) and the ADHD domains (Table 13). Family dysfunction did not moderate the relation between working memory (DSB) and parent-rated inattention or parent-rated hyperactivity/impulsivity. Likewise, none of the main effects were significant for these criterion variables.

When teacher-rated inattention was considered as the criterion variable, the main effects model was significant, $\Delta F(2, 36) = 5.42$, $p = .009$, explaining an additional 21% of variance. Although both family dysfunction and working memory (DSB) predicted unique variance in teacher-rated inattention, the interaction between the two was not significant.

When teacher-rated hyperactivity/impulsivity was considered as the criterion variable, the main effects model was significant, $\Delta F(2, 37) = 4.30$, $p = .021$, and explained 19% of the variance. Although family dysfunction significantly predicted unique variance in teacher-rated hyperactivity/impulsivity, it did not moderate the relation between working memory (DSB) and teacher-rated hyperactivity/impulsivity.

Hypothesis 5

To test Hypothesis 5, a total of 16 moderated multiple regression analyses (a set of four analyses for each of the four endophenotypes as a predictor) were conducted to examine the moderating effect of child grit on the relation between the four endophenotypes (each examined separately) and the ADHD domains. Covariates were included in analyses when applicable. Results are presented in Tables 14 through 17.

Response Disinhibition as the Predictor

The first set of four moderated multiple regression analyses examined child grit as a moderator of the relation between response disinhibition and the ADHD domains (Table 14). When parent-rated inattention was considered as the criterion variable, the main effects model was significant, $\Delta F(2, 81) = 4.56$, $p = .013$, explaining 10% of the variance in parent-rated inattention. Although child grit was a significant predictor of unique variance in parent-rated inattention, it did not moderate the relation between response disinhibition and parent-rated inattention.

When parent-rated hyperactivity/impulsivity was considered as the criterion variable, the main effects model was significant, $\Delta F(2, 80) = 5.64$, $p = .005$, accounting for an additional 12% of the variance. Although both response disinhibition and child grit significantly contributed unique variance in parent-rated hyperactivity/impulsivity, the interaction between the two was not significant.

When teacher-rated inattention was considered as the criterion variable, the main effects model was marginally significant, $\Delta F(2, 36) = 2.71$, $p = .080$, due to unique variance attributed by response disinhibition. The interaction model was significant, $\Delta F(1, 35) = 4.37$, $p = .044$, accounting for an additional 9% of the variance in teacher-rated inattention. A *post-hoc* plot of the reduced model (Figure 3) showed that grittier children who exhibited lower response disinhibition were rated as less inattentive by their teachers compared to children with lower response disinhibition who scored lower on grit.

When teacher-rated hyperactivity/impulsivity was considered as the criterion variable, the interaction model was marginally significant $\Delta F(1, 36) = 3.43$, $p = .073$, explaining an additional 8% of the variance. A *post-hoc* plot (Figure 4) suggested that grittier children who exhibit greater response disinhibition are rated by their teachers as more hyperactive/impulsive compared to less gritty children with the same level of response disinhibition. Higher grit and lower response disinhibition was associated with the lowest level of hyperactive/impulsive symptoms, as rated by teachers.

RT Variability as the Predictor

The second set of four moderated multiple regression analyses examined child grit as a moderator of the relation between RT variability and the ADHD domains (Table 15). When parent-rated inattention was considered as the criterion variable, the main effects model was significant, $\Delta F(2, 81) = 4.47$, $p = .014$, accounting for 10% of the variance. Although child grit significantly predicted unique variance in parent-rated inattention, it did not moderate the relation between RT variability and parent-rated inattention.

When parent-rated hyperactivity/impulsivity was considered as the criterion variable, the main effects model was significant, $\Delta F(2, 80) = 4.68$, $p = .012$, explaining an additional 10% of the variance. Although child grit significantly predicted unique variance in parent-rated hyperactivity/impulsivity, it did not moderate the relation between RT variability and parent-rated hyperactivity/impulsivity.

When teacher-rated inattention was considered as the criterion variable, the main effects model was significant, $\Delta F(2, 36) = 3.31$, $p = .048$, explaining an additional 14% of the variance (only RT variability, not child grit, was marginally significant). Child grit did not moderate the relation between RT variability and teacher-rated inattention.

When teacher-rated hyperactivity/impulsivity was considered as the criterion variable, the main effects model was significant, $\Delta F\,(2,37) = 4.11$, $p = .024$, accounting for 18% of the variance.) Although both RT variability and child grit significantly predicted unique variance in teacher-rated hyperactivity/impulsivity, the interaction between the two was not significant.

Working Memory (DSF) as the Predictor

The third set of four moderated multiple regression analyses examined child grit as a moderator of the relation between working memory (DSF) and the ADHD domains (Table 16). When parent-rated inattention was considered as the criterion variable, the main effects model was significant, $\Delta F(2, 81) = 5.47$, $p = .006$, explaining 12% of the variance in parent-rated inattention. Child grit significantly predicted unique variance in parent-rated inattention but did not moderate the relation between working memory (DSF) and parent-rated inattention.

When parent-rated hyperactivity/impulsivity was considered as the criterion variable, the main effects model was significant, $\Delta F(2, 80) = 3.85$, $p = .025$, and accounted for an additional 8% of the variance. Child grit was a significant unique predictor in the main effects model and marginally moderated the relation between working memory (DSF) and parent-rated hyperactivity/impulsivity, $\Delta F(1, 79) = 2.91$, $p = .092$, explaining an additional 3% of the variance. A *post-hoc* plot of the reduced model

(Figure 5) showed that less gritty children with lower working memory abilities are rated by their parents as more hyperactive/impulsive compared to grittier children with lower working memory abilities. Children with higher working memory abilities are rated by their parents as less hyperactive/impulsive regardless of their grit.

When teacher-rated inattention was considered as the criterion variable, the main effects model was marginally significant, $\Delta F(2, 36) = 2.79$, $p = .075$, explaining an additional 12% of the variance in teacher-rated inattention due to working memory (DSF). Only working memory (DSF), not child grit, was marginally significant. Likewise, child grit did not moderate the relation between working memory (DSF) and teacher-rated inattention.

Finally, child grit marginally moderated the relation between working memory (DSF) and teacher-rated hyperactivity/impulsivity, $\Delta F(1, 36) = 2.86$, $p = .099$, explaining an additional 7% of the variance. A *post-hoc* plot (Figure 6) indicated that teachers rated less gritty children with lower working memory abilities as less hyperactive/impulsive compared to grittier children with lower working memory abilities. Children with higher working memory abilities and higher grit were rated by their teachers as less hyperactive/impulsive compared to less gritty children with the same working memory abilities.

Working Memory (DSB) as the Predictor

The fourth set of four moderated multiple regression analyses examined child grit as a moderator of the relation between working memory (DSB) and the ADHD domains (Table 17). When parent-rated inattention was considered as the criterion variable, the main effects model was significant, $\Delta F(2, 81) = 5.10$, $p = .008$, accounting for 11% of the variance. Although child grit significantly predicted unique variance in parent-rated inattention, it did not moderate the relation between working memory (DSB) and parent-rated inattention.

When parent-rated hyperactivity/impulsivity was considered as the criterion variable, the main effects model was significant, $\Delta F(2, 80) = 4.23$, $p = .018$, and explained 9% of the variance in parent-rated hyperactivity/impulsivity. Although child grit significantly predicted unique variance in parent-rated hyperactivity/impulsivity, it did not moderate the relation between working memory (DSB) and parent-rated hyperactivity/impulsivity.

When teacher-rated inattention was considered as the criterion variable, the main effects model was marginally significant, $\Delta F(2, 36) = 2.87$, $p = .070$, and explained an additional 12% of the variance in teacher-rated inattention. Only working memory (DSB), not child grit, was marginally significant. Likewise, child grit did not moderate the relation between working memory (DSB) and teacher-rated inattention.

Child grit did not moderate the relation between working memory (DSB) and teacher-rated hyperactivity/impulsivity, and none of the main effects were significant for this criterion variable.

Hypothesis 6

To test Hypothesis 6, four moderated multiple regression analyses were conducted to examine the moderating effect of child grit on the relation between family dysfunction and the ADHD domains with covariates as applicable. Results are presented in Table 18.

When considering parent-rated inattention as the criterion variable, the main effects model was significant, $\Delta F(2, 81) = 4.52$, $p = .014$, explaining 10% of the variance. Although child grit significantly predicted unique variance in parent-rated inattention, it did not moderate the relation between family dysfunction and parent-rated inattention.

When considering parent-rated hyperactivity/impulsivity as the criterion variable, the main effects model was significant, $\Delta F(2, 80) = 3.46$, $p = .036$, accounting for 8% of the variance. Although child grit significantly predicted unique variance in parent-rated hyperactivity/impulsivity, it did not moderate the relation between family dysfunction and parent-rated hyperactivity/impulsivity.

When considering teacher-rated inattention as the criterion variable, the marginally significant main effects model, $\Delta F = 2.68$, $p = .083$, accounted for 12% of the variance (only family dysfunction, not child grit, was marginally significant). Likewise, child grit did not moderate the relation between family dysfunction and teacher-rated inattention.

When considering teacher-rated hyperactivity/impulsivity as the criterion variable, the main effects model was not significant, $\Delta F(2, 37) = 2.23$, $p = .122$, but family dysfunction significantly predicted unique variance in teacher-rated hyperactivity/impulsivity. Child grit did not moderate the relation between family dysfunction and teacher-rated hyperactivity/impulsivity.

Hypothesis 7

Hypothesis 7 explored whether the influence of family dysfunction on endophenotypes' effect on ADHD symptoms depends on child grit. A total of 16 moderated multiple regression analyses testing 3-way interactions were conducted by using PROCESS (Hayes, 2013) macro for SPSS, model 3. Gender and IQ were accounted for as indicated. Results are presented in Tables 19 through 22.

Response Disinhibition as the Predictor

The first set of four moderated multiple regression analyses examined the interaction between response disinhibition, family dysfunction, and child grit when predicting the ADHD domains (Table 19). When predicting parent-rated inattention, child grit was a significant unique predictor, and the 2-way interaction between response disinhibition and child grit was significant. The 3-way interaction was not significant.

When predicting parent-rated hyperactivity/impulsivity, both response disinhibition and child grit were significant unique contributors, and the 2-way interaction between response disinhibition and family dysfunction was significant. The 3-way interaction was not significant.

When predicting teacher-rated inattention, the 3-way interaction between response disinhibition, family dysfunction, and child grit was significant, $\Delta F(1, 31) = 3.44$, $p = .016$, accounting for additional 11% of the variance in the model. *Post-hoc* plots of the reduced model (Figure 7 and 8) indicated that higher child grit attenuates the effect of lower family dysfunction on the relation between higher response disinhibition and teacher-rated inattention compared to lower child grit. Less gritty children with high response disinhibition are rated as more inattentive by their teachers even if they come from healthy families. Lower child grit does not make much difference in teacher-rated inattention, when the child exhibits lower response disinhibition and comes from a family with healthy functioning. Higher grit, however, appears to exacerbate the endophenotypic risk of high response disinhibition in children from dysfucntional families who are rated as more inattentive by their teachers compared to less gritty children. Lower grit appears to override the protective effect of low response disinhibition on teacher-rated inattention in chidlren from dysfunctional families.

When predicting teacher-rated hyperactivity/impulsivity, no significant main effects or interactions were detected.

RT Variability as the Predictor

The second set of four moderated multiple regression analyses examined the interaction between RT variability, family dysfunction, and child grit when predicting the ADHD domains (Table 20). When predicting parent-rated inattention, child grit was a significant unique predictor and the 2-way interaction between child grit and RT variability was marginally significant.

Working Memory (DSF) as the Predictor

The third set of four moderated multiple regression analyses examined the interaction between working memory (DSF), family dysfunction, and child grit when predicting the ADHD domains (Table 21). When predicting parent-rated inattention and parent-rated hyperactivity/impulsivity, child grit was a significant predictor. When predicting teacher-rated inattention, family dysfunction marginally predicted unique variance. When predicting teacher-rated hyperactivity/impulsivity, no significant main effects or interactions were detected. None of the 3-way interactions were significant when working memory (DSF) was the predictor.

Working Memory (DSB) as the Predictor

The fourth set of four moderated multiple regression analyses examined the interaction between working memory (DSB), family dysfunction, and child grit when predicting the ADHD domains (Table 22). When predicting parent-rated inattention and parent-rated hyperactivity/impulsivity, child grit was a significant predictor. When predicting teacher-rated inattention and teacher-rated hyperactivity/impulsivity, working memory (DSB) and family dysfunction significantly predicted unique variance. None of the 3-way interactions were significant when working memory (DSB) was the predictor.

CHAPTER IV – DISCUSSION

Summary of Findings and Link to the Literature

The current study's aim was to examine the possible influence of family dysfunction and child grit on the expression of endophenotypes as ADHD symptoms. Hypothesis 1 was partially supported in that 5 out of 16 correlations were significant between the four endophenotypes and ADHD symptoms when accounting for child gender and IQ as covariates as indicated. Specifically, response disinhibition predicted higher hyperactivity/impulsivity symptoms reported by parents, variability in RTs predicted greater teacher-reported ADHD symptoms, and working memory deficits predicted more attention difficulties reported by teachers. The results are in agreement with prior research that identified higher response disinhibition, greater RT variability, and worse working memory performance as ADHD endophenotypic deficits in children (Bidwell et al., 2007; Crosbie et al., 2013; Gau & Shang, 2010; Goos et al., 2009; Lin et al., 2015; Robins et al. 2012;).

Hypothesis 2 was also partially supported in that two out of four correlations between family dysfunction and ADHD symptoms were significant. Specifically, higher family dysfunction predicted higher teacher-rated inattention and teacher-rated hyperactivity/impulsivity. Thus, our findings provide further support for the established strong link between family dysfunction and ADHD symptoms; several research studies identified family environment as an influential factor contributing to the development or prevention of ADHD symptoms in children (Aurebach et al., 2017; Crea et al., 2013; Dvorsky & Langberg, 2016; Mulligan et al., 2011). The connection between healthy family environment and lower ADHD symptoms is important also because families with a child diagnosed with ADHD are more likely to experience stress and conflict compared to families without children diagnosed with ADHD (Limbers et al., 2011; Moen et al., 2014; Mulligan et al., 2011; Theule et al., 2013), and this stress directly worsens family functioning (Haydicky et al. 2015).

Hypothesis 3 was partially supported in that two out of four correlations between child grit and ADHD symptoms were significant. Specifically, higher grit predicted lower parent-reported ADHD symptoms. In a previous study, a negative correlation between grit and inattention, defined as out-of-control everyday mind wandering, indicated that less gritty adults may experience inattention difficulties (Ralph et al., 2017). This finding is in line with our study in that grittier children were rated by their parents as less distracted and less hyperactive/impulsive. Harnessing perseverance for future goals in children with ADHD symptoms may increase their ability to focus.

There was minimal support for Hypothesis 4. However, one finding indicates that the relation between response disinhibition and parent-rated ADHD domains depends on the levels of family dysfunction, meaning that greater family dysfunction exacerbates the effect of response disinhibition on parent-rated ADHD symptoms. Whereas none of the relations between other endophenotypes and ADHD symptoms were moderated by family dysfunction, family dysfunction significantly predicted unique variance in several main effect and interaction models. Thus, healthy family environment may be an influential, preventative factor of ADHD symptoms, particularly for those with response disinhibition (Henderson et al, 2003; Auerbach et al., 2017; Crea et al. 2013).

Analyses provided some evidence contrary to our Hypothesis 5, which predicted that child grit would attenuate the relation between endophenotypes and ADHD symptoms. Whereas there was a moderating effect of child grit on the relation between endophenotypes and ADHD symptoms, this effect was in the opposite direction to what was predicted. Specifically, higher levels of child grit exacerbated the effect of high response disinhibition on teacher-rated ADHD domains. Grittier children with higher response disinhibition were perceived as more inattentive and hyperactive/impulsive by their teachers compared to less gritty children with the same level of neuropsychological endophenotypic deficit. However, high grit seemed to be protective in children with low response disinhibition: these children were rated as less inattentive by their teachers compared to less gritty children with low response disinhibition. Thus, paradoxically, grit seems to attenuate ADHD symptoms in children who exhibit smaller endophenotypic deficits, while exacerbating ADHD symptoms in children who exhibit greater endophenotypic deficits, at least when it comes to response disinhibition.

High grit seemed to be a protective factor when moderating the relation of working memory deficits on parent-rated hyperactivity/impulsivity, which was in line with our predictions. Specifically, a higher level of grit attenuated the severity of hyperactivity/impulsivity symptoms reported by the parents regardless of working memory deficits. High grit was associated with lower parent-rated hyperactivity/impulsivity in children with lower working memory abilities compared to children with a lower level of grit and lower working memory deficits. In addition, child grit was a significant unique predictor of ADHD symptoms in several main effect or interaction models, indicating that it plays an important role in development of ADHD symptoms. However, paradoxically, high grit exacerbated the effect of low working memory abilities on hyperactivity/impulsivity ratings of the teachers. Grittier children with working memory deficits were rated by their teachers as more hyperactive/impulsive compared to less gritty children with the same endophenotypic deficits.

Because this study investigated child grit as a novel construct in relation to ADHD symptoms, there is a dearth of research studies that could explain such a pattern of results, particularly the paradoxical finding. One explanation may be that children with low inhibition control and poor impulse regulation may not think about long-term goals in the same way compared to children with other types of endophenotypic ADHD deficits (e.g., working memory). Thus, grit may have interacted with response disinhibition in this paradoxical fashion when compared to how it interacted with other endophenotypic ADHD deficits. Research shows that children who are perceived as impulsive tend to have difficulties with delaying immediate gratification (Gawrilow, Gollwithzer, & Oettingen, 2011; Sonuga-Barke, 2002) and thus possibly may be unable to assess, relate to, and reach their future goals. Indeed, children with ADHD do not attempt to delay their immediate gratification when presented with a specific future benefit (Gawrilow et al., 2011). Likewise, inattentive children regardless of grit level may have difficulty being aware of and/or following their future goals. However, Ralph et al. (2017) explored the association between two types of inattention—deliberate and unintentional brief mind wandering. They found that, at least in gritty adults, deliberate inattention, operationalized as purposeful wandering of the mind, is positively associated with pursuing future goals, whereas less gritty adults experience daily mind wandering outside of their control (Ralph et al., 2017). Their results suggest that grit may play different roles when interacting with different constructs, which may explain our paradoxical finding.

There was no support for Hypothesis 6. That is, child grit did not attenuate ADHD symptoms among children who come from families with higher levels of family dysfunction. It is possible that the effect of family dysfunction as an environmental factor is a powerful one, overriding the influence of child personal characteristics on ADHD symptoms.

Finally, findings did not support Hypothesis 7. Paradoxically, the magnitude of the effect of response disinhibition on teacher-rated inattention in more dysfunctional families was higher for children with higher levels of grit. Grittier children with high response disinhibition were actually rated as more inattentive by their teachers, if they came from families with poorer functioning compared to less gritty children. Child grit lowered inattentive symptoms ratings when the child presented with lower response disinhibition and lived in a less dysfunctional family. Our findings highlight a complex relation that likely exists between environment (e.g., family dysfunction) and individual characteristics of the child (e.g., grit), who is at genetic risk of developing ADHD symptoms. As mentioned previously, response disinhibition as an endophenotypic risk may interact with child grit and family dysfunction differently than other endophenotypic deficits (e.g., working memory), and its influence on endophenotypes may also differ based on the home or school environment. Self-reported ratings of child grit may vary across contexts. Indeed, children with better academic achievement who attend schools with a demanding curriculum tend to rate themselves as less gritty compared to lower achieving students who attend schools with an open enrollment and a less demanding curriculum (West et al., 2016). Thus, school environment may bias the student toward rating their perseverance and skills more or less critically (West et al., 2016). Moreover, grit may function either as a protective or a detrimental factor depending on the individual, who may differ from another individual in symptoms and context. For example, in the military, hopeless but gritty soldiers report lower suicidal ideation and fewer suicidal plans compared to hopeless but less gritty soldiers (Pennings, Law, Green, & Anestis, 2015). However, gritty individuals who report more non-suicidal self-injuries (NSSI) also report higher suicidal behaviors compared to less gritty individuals with the same level of NSSI behaviors (Anestis & Selby, 2015). These studies highlight the possibility that grit may be a positive or negative personal quality depending on behaviors and context.

Study Limitations and Future Directions

Our study has several shortcomings. The response rate from teachers was low (47.62%), which likely underpowered our analyses and limited our ability to interpret and generalize the results. It is possible that greater power yielded by an equal number of participants in the teacher sample would have detected more significant findings. Future studies may utilize various incentives to increase teacher response rates when collecting data about child ADHD symptoms from teachers.

It is unclear whether our findings with regard to working memory endophenotypes were influenced by a comorbid diagnosis of learning disability (LD) and ADHD, because 6 out of 20 children with ADHD were identified by their parents as also having a learning disability. Research reports similar working memory difficulties for children diagnosed with LD and children with both LD and ADHD diagnoses (Kuhn, Ise, Raddatz, Schwenk, & Dobel, 2016; Pelegrina, Capodieci, Carretti, & Cornoldi, 2015). Studies also identified lower working memory abilities in children diagnosed with LD, including verbal, numerical, and visuospatial working memory deficits (Malekpour, Aghababaei, & Abedi, 2013; Peng & Fuchs, 2016). However, research also shows that adults with learning disabilities demonstrate greater deficits in auditory than visual working memory, whereas adults diagnosed with ADHD show no differences between their auditory and visual working memory abilities (Liebel & Nelson, 2017).

Even though children served as primary raters for family functioning and grit measures, it is possible that their self-report may have been influenced by positive illusory bias (PIB; Hoza et al., 2004), which could have distorted the accuracy of the child reports of family dysfunction and child grit. More positive competence ratings made by children with ADHD compared to controls, were more prevalent in hyperactive/impulsive individuals (Owens & Hoza, 2003). Interestingly, parent frequent praise toward children with ADHD appears to decrease their PIB; in contrast, criticism seems to increase their PIB (Emeh & Mikami, 2012). It is possible that self-reported grit by children in our sample may have been influenced by the child's perception of family functioning, particularly for participants with more ADHD symptoms. However, the items of the Family Assessment Device measure of family dysfunction were concrete, specific, and comprehensible enough to enable children to endorse ratings as accurately as possible, even if living in highly dysfunctional families. With regard to the ratings of family environment, concern arose that parent reports may not be honest and could be biased due to social desirability. Nevertheless, future studies could include the effect of PIB when investigating the influence of family functioning and child grit on ADHD symptoms.

The current study was cross-sectional, and thus, it was not able to capture the influence of the variables of interest on the development of ADHD symptoms across time. Future longitudinal studies may better elucidate the complex relation between endophenotypes, changes in ADHD symptoms, and various environmental as well as personal characteristics of the developing child which, in turn, could provide information about interventions in specific time points or situations.

Another limitation is that our study was correlational in nature, which prevents any causal inferences or the ability to determine any clear directional effects in the relations between the variables. Without an experimental manipulation of the variables, it is unclear whether ADHD symptoms influence family dysfunction, make children less (or more) gritty, and eventually cause or worsen endophenotypic deficits, or vice versa. It is also possible that other variables or constructs are responsible for the observed relations between ADHD endophenotypes, child grit, family dysfunction, and ADHD symptoms. Future longitudinal research may attempt to test the temporal sequence of the variables in a quasi-experimental design to provide further support for the directionality of the relations among variables.

Conclusions and Clinical Implications

Strengths of our study include collecting data from multiple informants (i.e., children, parents, and teachers) and utilization of multiple methods including indirect and direct testing (e.g., self-reports, objective laboratory tasks, standardized measures). This applied research underscored the influence of family functioning and child grit on the relation of genetic risks for ADHD and mental health outcomes. Healthy family functioning appears to have a potential effect on the expression of genetic vulnerability into ADHD symptoms, which in turn likely influences future academic, social, and occupational problems. Clinical implications of this study include the possibility of interventions aimed at improving family functioning of children diagnosed with ADHD. Home atmosphere and parenting practices likely contribute to behavioral difficulties of children who are at risk for developing full-blown inattentive and hyperactive/impulsive symptoms. Although the influence of child grit on the development of ADHD symptoms in children who exhibit endophenotypic deficits is quite complex, child grit plays an important role in predicting the severity of inattentive or hyperactive/impulsive symptoms of the child who also exhibits endophenotypic deficits. Child grit appears to be protective at least in the working memory domain. Therefore, the influence of child grit on ADHD symptoms warrants further research.

APPENDIX A – TABLES

Table A1. *Sample Characteristics: Child and Parent Demographics*

Characteristic	Full sample (*N* = 84)	Subsample (*N* = 40)
Child	*n* (%)	*n* (%)
Age	*M* = 14.20 (*SD* = 7.60)	*M* = 13.80 (*SD* = 2.09)
11	13 (15.5)	8 (20.0)
12	20 (23.8)	6 (15.0)
13	12 (14.3)	4 (10.0)
14	17 (20.2)	5 (12.5)
15	8 (9.5)	7 (17.5)
16	6 (7.1)	5 (12.5)
17	7 (8.3)	5 (12.5)
IQ	*M* = 100.73 (*SD* = 12.88)	*M* = 100.45 (*SD* = 13.72)
Gender	*M* = .49 (*SD* = .50)	*M* = .40 (*SD* = .50)
Male	43 (51.2)	24 (60.0)
Female	41 (48.8)	16 (40.0)
Ethnicity		
Not Hispanic or Latino	81 (96.4)	38 (95.0)
Hispanic or Latino	2 (2.4)	1 (2.5)
Missing	1 (1.2)	1 (2.5)
Race		
Black or African American	24 (28.6)	7 (17.5)
Asian	1 (1.2)	0 (0.0)
White or Caucasian	53 (63.1)	31 (77.5)
Native American/Alaskan Native	1 (1.2)	1 (2.5)
Missing	5 (6.0)	1 (2.5)
Race dichotomized		
White or Caucasian	53 (63.1)	31 (77.5)
Non-White	26 (31.0)	8 (20.0)
Missing	5 (6.0)	1 (2.5)
ADHD diagnosis		
No	64 (76.2)	29 (72.5)
Yes	20 (23.8)	11 (27.5)

Table A1 (continued).

Characteristic	Full sample (*N* = 84)	Subsample (*N* = 40)
Child	*n* (%)	*n* (%)
ADHD presentation		
Yes, predominantly inattentive	2 (2.4)	1 (2.5)
Yes, predominantly hyp/imp	3 (3.6)	3 (7.5)
Yes, combined	10 (11.7)	3 (7.5)
No subtype specified	2 (2.4)	2 (5.0)
Missing	3 (3.6)	2 (5.0)
Not applicable	64 (76.2)	29 (72.5)
Parent	*n* (%)	*n* (%)
Age	*M* = 42.51 (*SD* = 10.28)	*M* = 41.23 (*SD* = 8.08)
Gender		
Male	13 (15.5)	8 (20.0)
Female	71 (84.5)	32 (80.0)
Ethnicity		
Not Hispanic or Latino	80 (95.2)	37 (92.5)
Hispanic or Latino	2 (2.4)	1 (2.5)
Missing	2 (2.4)	2 (2.4)
Race		
Black or African American	24 (28.6)	6 (15.0)
Asian	1 (1.2)	0 (0.0)
White or Caucasian	58 (69.0)	34 (85.0)
Missing	1 (1.2)	0 (0.0)
Race dichotomized		
White or Caucasian	58 (69.0)	34 (85.0)
Non-White	25 (29.8)	6 (15.0)
Missing	1 (1.2)	0 (0.0)

Table A1 (continued).

Characteristic	Full sample (*N* = 84)	Subsample (*N* = 40)
Parent	*n* (%)	*n* (%)
Family Income		
$0 - $4,999	2 (2.4)	1 (2.5)
$5,000 - $9,999	1 (1.2)	1 (2.5)
$10,000 - $14,999	1 (1.2)	1 (2.5)
$15,000 - $24,999	10 (11.9)	3 (7.5)
$25,000 - $34,999	13 (15.5)	5 (12.5)
$35,000 - $49,999	14 (16.7)	8 (20.0)
$50,000 - $74,999	11 (13.1)	6 (15.0)
$75,000 - $99,999	9 (10.7)	7 (17.5)
$100,000 - $124,999	11 (13.1)	5 (12.5)
$125,000 - $149,999	1 (1.2)	0 (0.0)
$150,000 - $174,999	4 (4.8)	2 (5.0)
$175,000 - $199,999	1 (1.2)	1 (2.5)
$200,000 and above	4 (4.8)	0 (0.0)
Missing	2 (2.4)	0 (0.0)

Note. Subsample of *N* = 40 had teacher data; *M* = mean; *SD* = standard deviation; ADHD = attention deficit/hyperactivity disorder; Hyp/imp = hyperactive/impulsive

Table A2. *Descriptives of Variables of Interest (N = 84, full sample)*

			Range				
	M	*SD*	Potential	Actual	Skew	Kurtosis	Cronbach's alpha
Response disinhibition	4.64	5.32	0-125	0-22.1	1.88	3.21	-
RT variability	93.09	36.84	0+	36.39-196.91	.63	.01	-
Working memory (DSF)	5.35	1.14	0-9	2-8	.14	.29	-
Working memory (DSB)	4.33	1.25	0-9	2-8	.83	.56	-
Family dysfunction	22.11	5.07	12-48	12-37	.94	.89	.80
Child grit	3.44	.64	0-8	1.88-4.75	.26	-.53	.70
Parent-rated inattention	9.51	7.98	0-27	0-27	.79	.53	.96
Parent-rated hyp/imp	6.61	6.55	0-27	0-26	1.16	.50	.90
Teacher-rated inattention [a]	9.23	7.65	0-27	0-27	.89	-.14	.95
Teacher-rated hyp/imp [a]	4.15	4.94	0-27	0-17	1.08	.11	.92
Parent-rated ADHD Total	16.12	13.67	0-54	0-49	.92	-.20	.96
Teacher-rated ADHD Total [a]	13.38	11.42	0-54	0-35	.73	-.87	.95

Note. M = mean; *SD* = standard deviation; RT = reaction time; DSF = digit span forward; DSB = digit span backward; Hyp/imp = hyperactivity/impulsivity. Response disinhibition was calculated as the number of commission errors across all no-go trials of the Go/No-Go Task in Inquisit; RT variability was computed as the standard deviation of reaction times on correct go trials of the Go/No-Go Task in Inquisit; Working memory (DSF) was measured by the maximum number of digits recalled correctly before making two consecutive errors on the Visual Digit Span Task Forward in Inquisit; Working memory (DSB) was measured by the maximum number of digits recalled correctly before making two consecutive errors on the Visual Digit Span Task Backward in Inquisit; Family dysfunction was measured as the General Functioning Scale Total score of the McMaster Family Assessment Device (where *higher* scores represent more *dysfunction*); Child grit was measured by the Short Grit Scale Average score; Parent-rated inattention was measured by the Vanderbilt ADHD Diagnostic Parent Ratings Scale sum score on the Inattention subscale; Parent-rated hyperactivity/impulsivity was measured by the Vanderbilt ADHD Diagnostic Parent Ratings Scale sum score on the hyperactivity/impulsivity subscale; Teacher-rated inattention was measured by the Vanderbilt ADHD Diagnostic Teacher Ratings Scale sum score on the Inattention subscale; Teacher-rated hyperactivity/impulsivity was measured by the Vanderbilt ADHD Diagnostic Teacher Ratings Scale sum score on the hyperactivity/impulsivity subscale; Parent-rated ADHD Total was measured by the Vanderbilt ADHD Diagnostic Parent Ratings Scale Total score of both the inattention and hyperactivity/impulsivity subscales; Teacher-rated ADHD Total was measured by the Vanderbilt ADHD Diagnostic Teacher Ratings Scale Total score of both the inattention and hyperactivity/impulsivity subscales.

[a] *N* = 40 for teacher-rated variables.

Table A3. *Descriptives of Variables of Interest (N = 40, subsample)*

			Range				
	M	*SD*	Potential	Actual	Skew	Kurtosis	Cronbach's alpha
Response disinhibition	4.50	4.56	0-125	0-20	1.87	3.53	-
RT variability	89.55	36.39	0+	36.39-165.32	.23	-.89	-
Working memory (DSF)	5.58	.98	0-9	4-8	.29	-.31	-
Working memory (DSB)	4.35	1.27	0-9	2-7	.47	-.43	-
Family dysfunction	22.73	5.11	12-48	15-36	.93	.61	.83
Child grit	3.32	.65	0-8	1.88-4.38	-.06	-.77	.72
Parent-rated inattention	11.13	8.29	0-27	0-27	.52	-1.00	.96
Parent-rated hyp/imp	6.93	6.15	0-27	0-20	.86	-.29	.88
Teacher-rated inattention	9.23	7.65	0-27	0-27	.89	-.14	.95
Teacher-rated hyp/imp	4.15	4.95	0-27	0-17	1.08	.11	.92
Parent-rated ADHD Total	18.05	13.62	0-54	0-46	.53	-.98	.96
Teacher-rated ADHD Total	13.37	11.42	0-54	0-35	.73	-.87	.95

Note. M = mean; *SD* = standard deviation; RT = reaction time; DSF = digit span forward; DSB = digit span backward; Hyp/imp = hyperactivity/impulsivity. Response disinhibition was calculated as the number of commission errors across all no-go trials of the Go/No-Go Task in Inquisit; RT Variability was computed as the standard deviation of reaction times on correct go trials of the Go/No-Go Task in Inquisit; Working memory (DSF) was measured by the maximum number of digits recalled correctly before making two consecutive errors on the Visual Digit Span Task Forward in Inquisit; Working memory (DSB) was measured by the maximum number of digits recalled correctly before making two consecutive errors on the Visual Digit Span Task Backward in Inquisit; Family dysfunction was measured as the General Functioning Scale Total score of the McMaster Family Assessment Device; Child grit was measured by the Short Grit Scale Average score; Parent-rated inattention was measured by the Vanderbilt ADHD Diagnostic Parent Ratings Scale sum score on the Inattention subscale; Parent-rated hyperactivity/impulsivity was measured by the Vanderbilt ADHD Diagnostic Parent Ratings Scale sum score on the hyperactivity/impulsivity subscale; Teacher-rated inattention was measured by the Vanderbilt ADHD Diagnostic Teacher Ratings Scale sum score on the Inattention subscale; Teacher-rated hyperactivity/impulsivity was measured by the Vanderbilt ADHD Diagnostic Teacher Ratings Scale sum score on the hyperactivity/impulsivity subscale; Parent-rated ADHD Total was measured by the Vanderbilt ADHD Diagnostic Parent Ratings Scale Total score of both the inattention and hyperactivity/impulsivity subscales; Teacher-rated ADHD Total was measured by the Vanderbilt ADHD Diagnostic Teacher Ratings Scale Total score of both the inattention and hyperactivity/impulsivity subscales.

Table A4. *Correlations among Variables of Interest (N = 84. full sample)*

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Response disinhibition	-	.581***	-.147	-.149	.028	-.089	.07	.252*	.349*	.160
2. RT variability		-	-.23*	-.326**	.142	-.231*	.071	.272*	.397*	.425**
3. Working memory (DSF)			-	.259*	-.076	.146	-.185†	-.181	-.341*	-.039
4. Working memory (DSB)				-	.177	.028	-.120	-.151	-.385*	-.294†
5. Family dysfunction					-	-.382***	.149	.143	.343*	.322*
6. Child grit						-	-.315**	-.297**	-.229	-.081
7. Parent-rated inattention							-	.768***	.261	.015
8. Parent-rated hyp/imp								-	.276†	.246
9. Teacher-rated inattention [a]									-	.625***
10. Teacher-rated hyp/imp [a]										-

Note. RT = reaction time; DSF = digit span forward; DSB = digit span backward; Hyp/imp = hyperactivity/impulsivity.

[a] $N = 40$ for all correlations with teacher-rated variables.

† trend; $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

Table A5. *Correlations among Variables of Interest (N = 40, subsample)*

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Response disinhibition	-	.558***	-.249	-.363*	.154	-.063	.171	.211	.349*	.160
2. RT variability		-	-	-.502***	.386*	-.273†	.093	.151	.397*	.425**
3. Working memory (DSF)			-	.286†	-.218	.324*	-.327*	-.251	-.341*	-.039
4. Working memory (DSB)				-	-.008	.191	-.221	-.249	-.385*	-.294†
5. Family dysfunction					-	-.423**	.181	.282†	.343*	.322*
6. Child grit						-	-.295†	-.233	-.229	-.081
7. Parent-rated inattention							-	.777***	.261	.015
8. Parent-rated hyp/imp								-	.276†	.246
9. Teacher-rated inattention									-	.625***
10. Teacher-rated hyp/imp										-

Note. RT = reaction time; DSF = digit span forward; DSB = digit span backward; Hyp/imp = hyperactivity/impulsivity.
† trend; p < .10. * p < .05. ** p < .01. *** p < .001.

Table A6. *Correlations between Potential Covariates and Criterion Variables*

	Parent-rated inattention	Parent-rated hyp/imp	Teacher-rated inattention [a]	Teacher-rated hyp/imp [a]
Child age	.147	.075	.033	-.057
Child	-.162	-.161	-.315*	-.234
Child race [b]	.070	-.004	-.079	-.005
K-BIT IQ	-.143	-.226*	-.277†	-.219

Note. Hyp/imp = hyperactivity/impulsivity; K-BIT = Kaufman Brief Intelligence Test (2nd edition); child gender was coded as 0 = male, 1 = female; child race was coded as 0 = Non-White, 1 = White.
[a] *N* = 40 for all correlations with teacher-rated variables.
[b] Due to missing child race information for 5 participants, *N* = 79 for parent-rated ADHD domains and *N* = 39 for teacher-rated ADHD domains when correlated with race.
[†] trend; $p < .10$. [*] $p < .05$.

Table A7. *Correlations between Endophenotypes and ADHD Domains*

	Parent-rated inattention	Parent-rated hyp/imp	Teacher-rated inattention [a]	Teacher-rated hyp/imp [a]
Response inhibition	.070	.232*b	.294†c	.160
RT variability	.071	.215†b	.372*c	.425**
Working memory (DSF)	-.185†	-.127b	-.346*c	-.039
Working memory (DSB)	-.120	-.133b	-.331*c	-.294†

Note. RT = reaction time; DSF = digit span forward; DSB = digit span backward; Hyp/imp = hyperactivity/impulsivity.
[a] *N* = 40 for all correlations with teacher-rated variables.
[b] Partial correlations (IQ as covariate).
[c] Partial correlations (gender as covariate, coded as 0 = male, 1 = female)
[†] trend; $p < .10$. [*] $p < .05$. [**] $p < .01$.

Table A8. *Correlations between Family Dysfunction and ADHD Domains*

	Family dysfunction
Parent-rated inattention	.149
Parent-rated hyp/imp	.123[b]
Teacher-rated inattention[a]	.349[*c]
Teacher-rated hyp/imp[a]	.322[*]

Note. Hyp/imp = hyperactivity/impulsivity.
[a] $N = 40$ for all correlations with teacher-rated variables.
[b] Partial correlations (IQ as covariate).
[c] Partial correlations (gender as covariate, coded as 0 = male, 1 = female)
[*] $p < .05$.

Table A9. *Correlations between Child Grit and ADHD Domains*

	Child grit
Parent-rated inattention	-.315[**]
Parent-rated hyp/imp	-.281[**b]
Teacher-rated inattention [a]	-.226[c]
Teacher-rated hyp/imp [a]	-.081

Note. Hyp/imp = hyperactivity/impulsivity.
[a] $N = 40$ for all correlations with teacher-rated variables.
[b] Partial correlations (IQ as covariate).
[c] Partial correlations (gender as covariate, coded as 0 = male, 1 = female).
[**] $p < .01$.

Table A10. *Family Dysfunction as a Moderator of the Relation between Response Disinhibition and ADHD Domains*

	Parent-rated inattention (*N* = 84)	Parent-rated hyp/imp (*N* = 84)	Teacher-rated inattention (*N* = 40)	Teacher-rated hyp/imp (*N* = 40)
Control Model R^2	--	**.05***	**.01***	--
Child IQ	--	-.12 (.06)*	--	--
Child gender	--	--	-4.84 (2.38)*	--
Main Effects Model R^2	**.03**	**.17**†	**.26***	**.12**
Main Effects Model $R^2\Delta$	**.03**	**.07**†	**.16***	**.12**
Child IQ	--	-.09 (.05)†	--	--
Child gender	--	--	-3.75 (2.28)	--
Response disinhibition	.01 (.17)	.28 (.13)*	.41 (.25)	.12 (.17)
Family dysfunction	.23 (.17)	.15 (.14)	.44 (.22)*	.30 (.15)†
Interaction Model R^2	**.08**†	**.15***	**.29***	**.15**
Interaction Model $R^2\Delta$	**.05***	**.04**†	**.02**	**.03**
Child IQ	--	-.08 (.05)	--	--
Child gender	--	--	-4.20 (2.32)†	--
Response disinhibition (RD)	.09 (.16)	.27(.13)*	.55 (.29)†	.24 (.20)
Family dysfunction (FD)	.24 (.17)	.16 (.14)	.43 (.22)†	.28 (.15)†
RD X FD	.07 (.03)*	.05 (.03)†	-.06 (.05)	-.04 (.04)

Note: R^2 and $R^2\Delta$ statistics are shown in **bold** for each model. Unstandardized regression coefficients are reported for each predictor. Standard errors are shown in parentheses. Child gender was coded as 0 = male, 1 = female. Hyp/imp = hyperactivity/impulsivity.
† trend; $p < .10$. * $p < .05$.

Table A11. *Family Dysfunction as a Moderator of the Relation between Reaction Time Variability and ADHD Domains*

	Parent-rated inattention (N = 84)	Parent-rated hyp/imp (N = 84)	Teacher-rated inattention (N = 40)	Teacher-rated hyp/imp (N = 40)
Control Model R^2	--	**.05***	**.10***	--
Main Effects Model R^2	**.03**	**.10**†	**.27***	**.21***
Main Effects Model $R^2\Delta$	**.03**	**.05**†	**.17***	**.21***
Child IQ	--	-.08 (.06)	--	--
Child gender	--	--	-4.10 (2.22)†	--
RT variability	.01 (.02)	.04 (.02)†	.06 (.03)†	.05 (.02)*
Family dysfunction	.22 (.18)	.13 (.14)	.34 (.23)	.18 (.15)
Interaction Model R^2	**.03**	**.11**†	**.27***	**.23***
Interaction Model $R^2\Delta$	**.01**	**.01**	**.00**	**.02**
Child IQ	--	-.08 (.06)	--	--
Child gender	--	--	-4.05 (2.26)†	--
RT variability (RTV)	.01 (.02)	.04 (.02)†	.05 (.03)	.04 (.02)†
Family dysfunction (FD)	.22 (.18)	.12 (.14)	.36 (.24)	.21 (.16)
RTV X FD	.00 (.01)	.00(.00)	-.00 (.01)	-.01 (.01)

Note: R^2 and $R^2\Delta$ statistics are shown in **bold** for each model. Unstandardized regression coefficients are reported for each predictor. Standard errors are shown in parentheses. Child gender was coded as 0 = male, 1 = female. RT = reaction time. Hyp/imp = hyperactivity/impulsivity.
† trend; $p < .10$. * $p < .05$.

Table A12. *Family Dysfunction as a Moderator of the Relation between Working Memory (DSF) and ADHD Domains*

	Parent-rated inattention (N = 84)	Parent-rated hyp/imp (N = 84)	Teacher-rated inattention (N = 40)	Teacher-rated hyp/imp (N = 40)
Control Model R^2	--	**.05***	**.10***	--
Main Effects Model R^2	**.05**	**.07**	**.28***	**.11**
Main Effects Model $R^2\Delta$	**.05**	**.03**	**.18***	**.11**
Child IQ	--	-.09 (.06)	--	--
Child gender	--	--	-4.53 (2.12)*	--
Working memory (DSF)	-1.23 (.76)	-.71 (.64)	+2.009 (1.13)†	.16 (.80)
Family dysfunction	.21 (.17)	.15 (.14)	.41 (.22)†	.32 (.15)
Interaction Model R^2	**.06**	**.10**†	**.30***	**.11**
Interaction Model $R^2\Delta$	**.01**	**.02**	**.02**	**.01**
Child IQ	--	-.09 (.06)	--	--
Child gender	--	--	-4.75 (2.20)*	--
Working memory (DSF)	-.18 (.77)	-.65 (.64)	-1.70 (1.20)	.02 (.86)
Family dysfunction (FD)	.20 (.17)	.13 (.14)	.48 (.23)*	.29 (.16)
DSF X FD	-.11 (.12)	-.14 (.10)	-.19 (.18)	.07 (.13)

Note: R^2 and $R^2\Delta$ statistics are shown in **bold** for each model. Unstandardized regression coefficients are reported for each predictor. Standard errors are shown in parentheses. Child gender was coded as 0 = male, 1 = female. DSF = digit span forward. Hyp/imp = hyperactivity/impulsivity.
† trend; $p < .10$. * $p < .05$.

Table A13. *Family Dysfunction as a Moderator of the Relation between Working Memory (DSB) and ADHD Domains*

	Parent-rated inattention (N = 84)	Parent-rated hyp/imp (N = 84)	Teacher-rated inattention (N = 40)	Teacher-rated hyp/imp (N = 40)
Control Model R^2	--	**.05***	**.10***	--
Main Effects Model R^2	**.05**	**.09**	**.31****	**.19***
Main Effects Model $R^2\Delta$	**.05**	**.04**	**.21****	**.19***
Child IQ	--	-.10 (.06) †	--	--
Child gender	--	--	-3.36 (-.22)	--
Working memory (DSB)	-.97 (.71)	-.84 (.57)	-1.96 (-.33)*	-1.13 (.58)†
Family dysfunction	.28 (.17)	.19 (.14)	.50 (.33)*	.31 (.14)*
Interaction Model R^2	**.05**	**.10**†	**.31***	**.19**†
Interaction Model $R^2\Delta$	**.00**	**. 01**	**.00**	**.00**
Child IQ	--	-.10 (.06) †	--	--
Child gender	--	--	-3.33 (2.27)	--
Working memory (DSB)	-1.03 (.72)	-.74 (.58)	-1.97 (.88)*	-1.12 (.58)†
Family dysfunction (FD)	.28 (.18)	.21 (.14)	.50 (.21)*	.30 (.15)*
DSB X FD	.07 (.14)	-.12 (.11)	-.02 (.20)	.05 (.14)

Note: R^2 and $R^2\Delta$ statistics are shown in **bold** for each model. Unstandardized regression coefficients are reported for each predictor. Standard errors are shown in parentheses. Child gender was coded as 0 = male, 1 = female. DSB = digit span backward. Hyp/imp = hyperactivity/impulsivity.
† trend; $p < .10$. * $p < .05$. ** $p < .01$.

Table A14. *Child Grit as a Moderator of the Relation between Response Disinhibition and ADHD Domains*

	Parent-rated inattention (N = 84)	Parent-rated hyp/imp (N = 84)	Teacher-rated inattention (N = 40)	Teacher-rated hyp/imp (N = 40)
Control Model R^2	--	**.05***	**.10***	--
Child IQ	--	-.12 (.06)*	--	--
Child gender	--	--	-4.85 (2.38)*	--
Main Effects Model R^2	**.10***	**.17****	**.22**†	**.03**
Main Effects Model $R^2\Delta$	**.10***	**.12****	**.12**†	**.03**
Child IQ	--	-.09 (.05)	--	--
Child gender	--	--	-3.65 (2.35)	--
Response disinhibition	.06 (.16)	.26 (.13)*	.47 (.26)†	.17 (.18)
Child grit	-3.91(1.33)**	-2.68 (1.06)*	-2.35 (1.73)	-54 (1.23)
Interaction Model R^2	**.12***	**.17****	**.30***	**.12**
Interaction Model $R^2\Delta$	**.02**	**.00**	**.09***	**.08**†
Child IQ	--	-.09 (.05)	--	--
Child gender	--	--	-4.03 (2.26)†	--
Response disinhibition (RD)	.06 (.16)	.26(.13)*	.34 (.25)	.09 (.18)
Child grit (CG)	-3.92 (1.32)*	-2.68 (.1.07)*	-2.03 (1.66)	-.34 (1.20)
RD X CG	.39 (.27)	-.01 (.22)	.98 (.47)*	.62 (.33)†

Note: R^2 and $R^2\Delta$ statistics are shown in **bold** for each model. Unstandardized regression coefficients are reported for each predictor. Standard errors are shown in parentheses. Child gender was coded as 0 = male, 1 = female. Hyp/imp = hyperactivity/impulsivity.
† trend; $p < .10$. * $p < .05$. ** $p < .01$.

Table A15. *Child Grit as a Moderator of the Relation between Reaction Time Variability and ADHD Domains*

	Parent-rated inattention (N = 84)	Parent-rated hyp/imp (N = 84)	Teacher-rated inattention (N = 40)	Teacher-rated hyp/imp (N = 40)
Control Model R^2	--	**.05** *	**.10** *	--
Main Effects Model R^2	**.10** *	**. 15** *	**.24** *	**.18** *
Main Effects Model $R^2\Delta$	**.10** *	**.10** *	**.14** *	**.18** *
Child IQ	--	-.07 (.06)	--	--
Child gender	--	--	-4.01 (2.27) †	--
RT variability	.00 (.02)	.03 (.02) †	.07 (.03) *	.06 (.02) **
Child grit	-4.00 (1.36) **	-2.50 (1.09) *	-1.51 (1.77)	.29 (1.17) *
Interaction Model R^2	**.13** *	**.15** **	**.25** *	**.20** *
Interaction Model $R^2\Delta$	**.03**	**.00**	**.01**	**.02**
Child IQ	--	-.08 (.06)	--	--
Child gender	--	--	-3.98 (2.29) †	--
RT variability (RTV)	.01 (.02)	.03 (.02)	.07 (.03) *	.06 (.02) *
Child grit (CG)	-4.16 (1.35) **	-2.48 (1.10) *	-1.60 (1.79)	.38 (1.17)
RTV X CG	.06 (.04)	-.01(.03)	-.04 (.06)	.04 (.04)

Note: R^2 and $R^2\Delta$ statistics are shown in **bold** for each model. Unstandardized regression coefficients are reported for each predictor. Standard errors are shown in parentheses. Child gender was coded as 0 = male, 1 = female. RT = reaction time. Hyp/imp = hyperactivity/impulsivity.

† trend; $p < .10$. * $p < .05$. ** $p < .01$.

Table A16. *Child Grit as a Moderator of the Relation between Working Memory (DSF) and ADHD Domains*

	Parent-rated inattention (N = 84)	Parent-rated hyp/imp (N = 84)	Teacher-rated inattention (N = 40)	Teacher-rated hyp/imp (N = 40)
Control Model R^2	--	**.05***	**.10***	--
Main Effects Model R^2	**.12****	**.13***	**.22**†	**.01**
Main Effects Model $R^2\Delta$	**.12****	**.08***	**.12**†	**.01**
Child IQ	--	-.09 (.06)	--	--
Child gender	--	--	-4.58 (2.27)†	--
Working memory (DSF)	-.99 (.74)	-.55 (.63)	-2.25 (1.21)†	-.07 (.87)
Child grit	-3.70 (1.32)**	-2.73 (1.09)*	-1.42 (1.82)	-.58 (1.31)
Interaction Model R^2	**.14***	**.17****	**.23***	**.08**
Interaction Model $R^2\Delta$	**.03**	**.03**†	**.01**	**.07**†
Child IQ	--	-.10 (.06)†	--	--
Child gender	--	--	-4.73 (2.29)*	--
Working memory (DSF)	-1.04 (.74)	-.56 (.62)	-2.19 (1.22)†	.02 (.85)
Child grit (CG)	-3.05 (1.38)*	-2.14 (1.13)†	-1.59 (1.85)	-.84 (1.29)
DSF X CG	1.52 (.97)	1.35 (.79)†	-1.31 (1.64)	-1.93 (1.14)†

Note: R^2 and $R^2\Delta$ statistics are shown in **bold** for each model. Unstandardized regression coefficients are reported for each predictor. Standard errors are shown in parentheses. Child gender was coded as 0 = male, 1 = female. DSF = digit span forward. Hyp/imp = hyperactivity/impulsivity.
† trend; $p < .10$. * $p < .05$. ** $p < .01$.

Table A17. *Child Grit as a Moderator of the Relation between Working Memory (DSB) and ADHD Domains*

	Parent-rated inattention (N = 84)	Parent-rated hyp/imp (N = 84)	Teacher-rated inattention (N = 40)	Teacher-rated hyp/imp (N = 40)
Control Model R^2	--	**.05***	**.10***	--
Main Effects Model R^2	**.11****	**.14***	**.22**†	**.09**
Main Effects Model $R^2\Delta$	**.11****	**.09***	**.13**†	**.09**
Child IQ	--	-.09 (.05)†	--	--
Child gender	--	--	-3.56 (2.35)	--
Working memory (DSB)	-.72 (.67)	-.66 (.55)	-1.77 (.93)†	-1.12 (.62)†
Child grit	-3.92 (1.32)**	-2.81 (1.07)**	-1.90 (1.75)	-.20 (1.21)
Interaction Model R^2	**.11***	**.14***	**.24***	**.10**
Interaction Model $R^2\Delta$	**.00**	**. 00**	**.02**	**.01**
Child IQ	--	-.10 (.05)†	--	--
Child gender	--	--	-3.72 (2.36)	--
Working memory (DSB)	-.71 (.68)	-.67 (.55)	-1.65 (.94)†	-1.07 (.63)†
Child grit (CG)	-3.94 (1.33)**	-2.79 (1.09)*	-1.71 (1.77)	-.11 (1.23)
DSB X CG	-.17 (1.19)	.26 (.9711)	-1.65 (1.75)	-.80 (1.21)

Note: R^2 and $R^2\Delta$ statistics are shown in **bold** for each model. Unstandardized regression coefficients are reported for each predictor. Standard errors are shown in parentheses. Child gender was coded as 0 = male, 1 = female. DSB = digit span forward. Hyp/imp = hyperactivity/impulsivity.
† trend; p < .10. * p < .05. ** p < .01.

Table A18. *Child Grit as a Moderator of the Relation between Family Dysfunction and ADHD Domains*

	Parent-rated inattention (*N* = 84)	Parent-rated hyp/imp (*N* = 84)	Teacher-rated inattention (*N* = 40)	Teacher-rated hyp/imp (*N* = 40)
Control Model R^2	--	**.05***	**.10***	--
Child IQ	--	-.12 (.06)*	--	--
Child gender	--	--	-4.85 (2.38)*	--
Main Effects Model R^2	**.10***	**.13***	**.22**†	**.11**
Main Effects Model $R^2\Delta$	**.10***	**.08***	**.12**†	**.11**
Child IQ	--	-.10 (.05)†	--	--
Child gender	--	--	-4.63 (2.28)*	--
Family dysfunction	.05 (.18)	.03 (.15)	.44 (.24)†	.34 (.17)*
Child grit	-3.80 (1.43)**	-2.76 (1.17)*	-1.07 (1.91)	.51 (1.30)
Interaction Model R^2	**.11***	**.13***	**.24***	**.11**
Interaction Model $R^2\Delta$	**.01**	**.00**	**.03**	**.00**
Child IQ	--	-.10 (.05)†	--	--
Child gender	--	--	-4.14 (2.32)†	--
Family dysfunction (FD)	.10 (.19)	.02 (.15)	.55 (.27)*	.33 (.18)†
Child grit (CG)	-3.71 (1.44)*	-2.77 (1.18)*	-.74 (1.93)	.48 (1.33)
FD X CG	.27 (.30)	-.01 (.24)	-4.14 (2.32)	-.03 (.27)

Note: R^2 and $R^2\Delta$ statistics are shown in **bold** for each model. Unstandardized regression coefficients are reported for each predictor. Standard errors are shown in parentheses. Child gender was coded as 0 = male, 1 = female. Hyp/imp = hyperactivity/impulsivity.
† trend; $p < .10$. * $p < .05$. ** $p < .01$.

Table A19. *Three-way Interaction (Response Disinhibition X Family Dysfunction X Child Grit) Predicting ADHD Domains*

	Parent-rated inattention (N = 84)	Parent-rated hyp/imp (N = 84)	Teacher-rated inattention (N = 40)	Teacher-rated hyp/imp (N = 40)
Control Model R^2	--	**.05***	**.10***	--
Main Effects Model R^2	**.10***	**.17***	**.27†**	**.12**
Main Effects Model $R^2\Delta$	**.10***	**.12***	**.17†**	**.12**
Child IQ	--	-.09 (.05)	--	--
Child gender	--	--	-3.71 (2.30)	--
Response disinhibition (RD)	.06 (.16)	.26 (.13)*	.41 (.25)	.12 (.17)
Family dysfunction (FD)	.05 (.18)	.03 (.14)	.39 (.24)	.32 (.17)†
Child grit (CG)	-3.75 (1.45)*	-2.59 (1.15)*	-1.10 (.1.87)	.50 (1.31)
Two-Way Model R^2	**.20***	**.22**	**.34**	**.21**
Two-Way Model $R^2\Delta$	**.10***	**.05**	**.07**	**.09**
RD X FD	.09 (.03)*	.06 (.03)*	-.06 (.06)	-.04 (.04)
RD X CG	.49 (.27)†	.06 (.22)	.73 (.53)	.49 (.37)
FD X CG	.16 (.29)	-.14 (.24)	.18 (.47)	-.14 (.33)
Three-Way Model R^2	**.21***	**.22***	**.45****	**.21**
Three-Way Model $R^2\Delta$	**.00**	**.00**	**.11***	**.00**
RD X FD X CG	.03 (.06)	.01 (.05)	.23 (.09)*	.01 (.07)

Note. R^2 and $R^2\Delta$ statistics are shown in **bold** for each model. Unstandardized regression coefficients are reported for each moderator. Standard errors are shown in parentheses. Child gender was coded as 0 = male, 1 = female. Hyp/imp = hyperactivity/impulsivity.

† trend; $p < .10$. * $p < .05$. ** $p < .01$.

Table A20. *Three-way Interaction (Reaction Time Variability X Family Dysfunction X Child Grit) Predicting ADHD Domains*

	Parent-rated inattention (N = 84)	Parent-rated hyp/imp (N = 84)	Teacher-rated inattention (N = 40)	Teacher-rated hyp/imp (N = 40)
Control Model R^2	--	**.05***	**.10***	--
Main Effects Model R^2	**.10***	**.15***	**.27**†	**.22***
Main Effects Model $R^2\Delta$	**.10***	**.10***	**.17**†	**.22***
Child IQ	--	-.07 (.06)	--	--
Child gender	--	--	-4.08 (2.25)†	--
RT variability (RTV)	-.00 (.02)	.03 (.02)	.06 (.03)	.05 (.02)*
Family dysfunction (FD)	.05 (.18)	.02 (.15)	.31 (.25)	.22 (.17)
Child grit (CG)	-3.81(1.47)*	-2.45 (1.18)*	-.67 (1.88)	.88 (1.24)
Two-Way Model R^2	**.16**	**.15**	**.32**	**.31**
Two-Way Model $R^2\Delta$	**.06**	**.00**	**.05**	**.09**
RTV X FD	.01 (.01)	.00 (.01)	-.00 (.01)	-.01 (.01)
RTV X CG	.08 (.04)†	.00 (.04)	-.10 (.07)	.05 (.05)
FD X CG	.33 (.31)	.06 (.26)	.54 (.49)	-.51 (.30)
Three-Way Model R^2	**.16**†	**.16**	**.35**†	**.33**†
Three-Way Model $R^2\Delta$	**.00**	**.00**	**.04**	**.01**
RTV X FD X CG	-.01 (.01)	.00 (.01)	.02 (.02)	.01 (.01)

Note. R^2 and $R^2\Delta$ statistics are shown in **bold** for each model. Unstandardized regression coefficients are reported for each moderator. Standard errors are shown in parentheses. Child gender was coded as 0 = male, 1 = female. RT = reaction time. Hyp/imp = hyperactivity/impulsivity.

† trend; $p < .10$. * $p < .05$.

Table A21. *Three-way Interaction (Working Memory DSF X Family Dysfunction X Child Grit) Predicting ADHD Domains*

	Parent-rated inattention (N = 84)	Parent-rated hyp/imp (N = 84)	Teacher-rated inattention (N = 40)	Teacher-rated hyp/imp (N = 40)
Control Model R^2	--	**.05***	**.10***	--
Main Effects Model R^2	**.12***	**.14**†	**.28***	**.11**
Main Effects Model $R^2\Delta$	**.12***	**.08**†	**.18***	**.11**
Child IQ	--	-.09 (.06)	--	--
Child gender	--	--	-4.52 (2.22)*	--
Working memory (DSF)	-.99 (.75)	-.55 (.63)	-2.06 (1.19)†	.09 (.84)
Family dysfunction (FD)	.05 (.18)	.03 (.15)	.40 (.24)	.34 (.17)†
Child grit (CG)	-3.56 (1.44)*	-2.65 (1.18)*	-.19 (1.92)	.47 (1.36)
Two-Way Model R^2	**.16**	**.17**	**.32**	**.14**
Two-Way Model $R^2\Delta$	**.04**	**.04**	**.04**	**.03**
DSF X FD	-.00 (.14)	-.09 (.12)	-.30 (.24)	.01 (.17)
DSF X CG	1.55 (1.15)	1.01 (.95)	-1.70 (2.15)	-1.41 (1.49)
FD X CG	.27 (.30)	-.05 (.25)	.04 (.47)	-.12 (.32)
Three-Way Model R^2	**.17***	**.20***	**.34**†	**.14**
Three-Way Model $R^2\Delta$	**.01**	**.03**	**.02**	**.00**
DSF X FD X CG	-.22 (.26)	-.32 (.21)	-.41 (.39)	.05 (.28)

Note. R^2 and $R^2\Delta$ statistics are shown in **bold** for each model. Unstandardized regression coefficients are reported for each moderator. Standard errors are shown in parentheses. Child gender was coded as 0 = male, 1 = female. DSF = digit span forward. Hyp/imp = hyperactivity/impulsivity.

† trend; $p < .10$. * $p < .05$.

Table A22. *Three-Way Interaction (Working Memory DSB X Family Dyfunction X Child Grit) Predicting ADHD Domains*

	Parent-rated inattention (N = 84)	Parent-rated hyp/imp (N = 84)	Teacher-rated inattention (N = 40)	Teacher-rated hyp/imp (N = 40)
Control Model R^2	--	**.05***	**.10***	--
Main Effects Model R^2	**.12***	**.14***	**.31***	**.20***
Main Effects Model $R^2\Delta$	**.12***	**.09***	**.21***	**.20***
Child IQ	--	-.09 (.05)†	--	--
Child gender	--	--	-3.37 (2.25)	--
Working memory (DSB)	-.79 (.69)	-.71 (.56)	-1.93 (.90)*	-1.23 (.59)*
Family dysfunction (FD)	.10 (.18)	.07 (.15)	.48 (.23)*	.37 (.16)*
Child grit (CG)	-3.63 (1.44)*	-2.62 (1.17)*	-.24 (1.86)	1.05 (1.27)
Two-Way Model R^2	**.13**	**.16**	**.32**	**.22**
Two-Way Model $R^2\Delta$	**.02**	**.01**	**.01**	**.02**
DSB X FD	.09 (.15)	-.12 (.12)	-.06 (.25)	.09 (.17)
DSB X CG	-.04 (1.25)	-.01 (1.03)	-.65 (2.08)	.22 (1.41)
FD X CG	.31 (.31)	-.04 (.25)	.22 (.42)	-.17 (.28)
Three-Way Model R^2	**.16†**	**.16$^{-\dagger}$**	**.33†**	**.24**
Three-Way Model $R^2\Delta$	**.03**	**.00**	**.01**	**.02**
DSB X FD X CG	-.44 (.29)	-.05 (.26)	-.31 (.39)	.21 (.27)

Note. R^2 and $R^2\Delta$ statistics are shown in **bold** for each model. Unstandardized regression coefficients are reported for each moderator. Standard errors are shown in parentheses. Child gender was coded as 0 = male, 1 = female. DSB = digit span backward. Hyp/imp = hyperactivity/impulsivity.
† trend; p < .10. * p < .05.

APPENDIX B – FIGURES

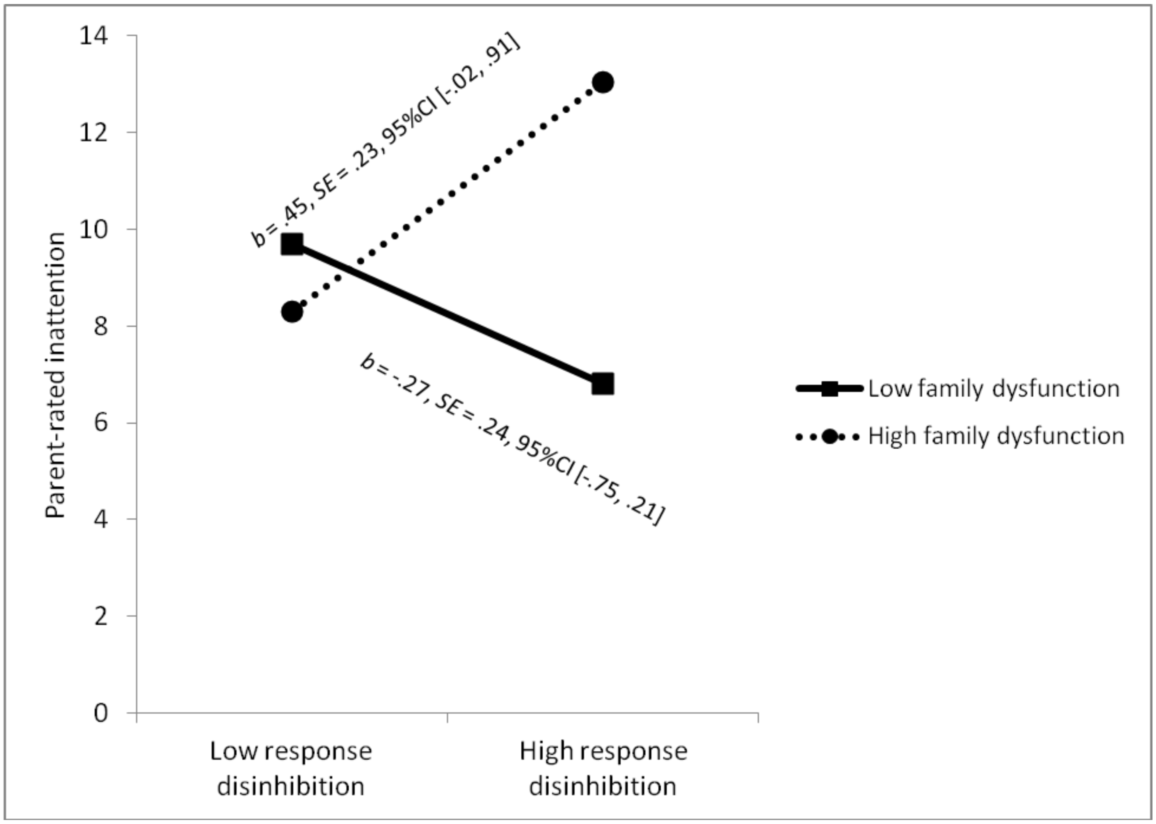

Figure A1. Significant interaction between response disinhibition and family dysfunction predicting parent-rated inattention.

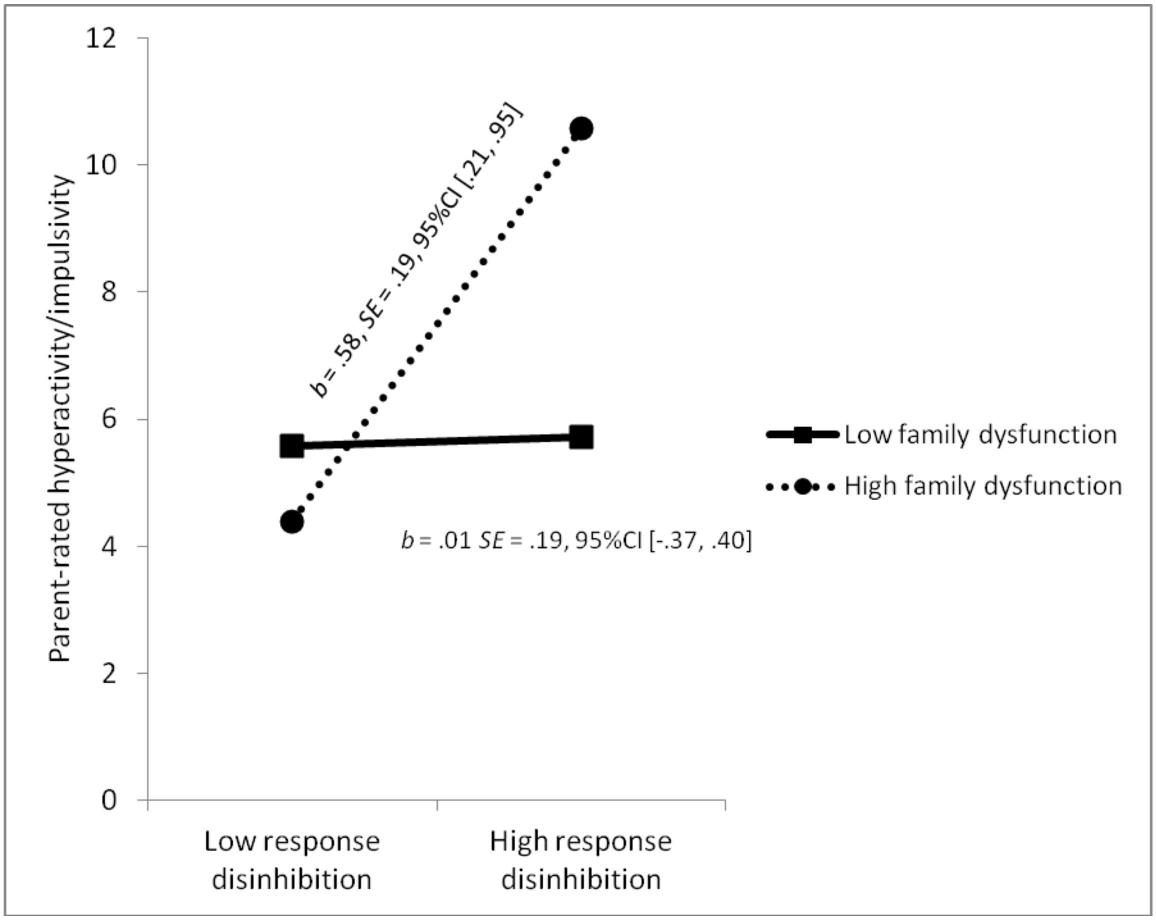

Figure A2. Marginally significant interaction between response disinhibition and family dysfunction predicting parent-rated hyperactivity/impulsivity.

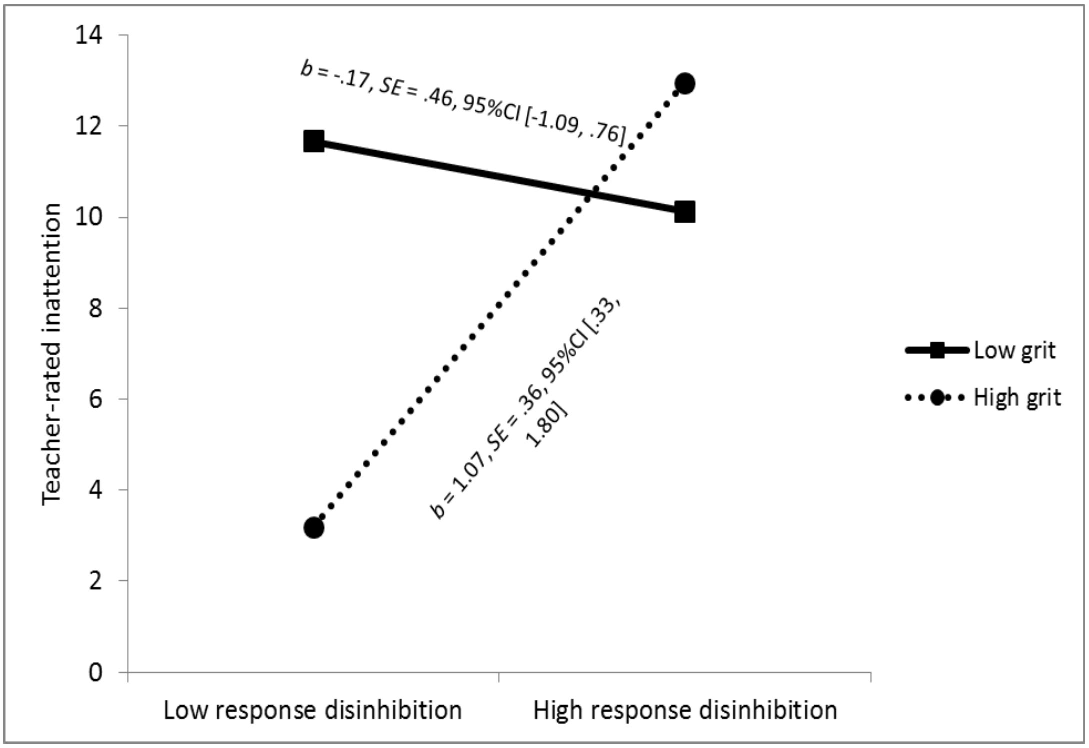

Figure A3. Significant interaction between response disinhibition and child grit predicting teacher-rated inattention.

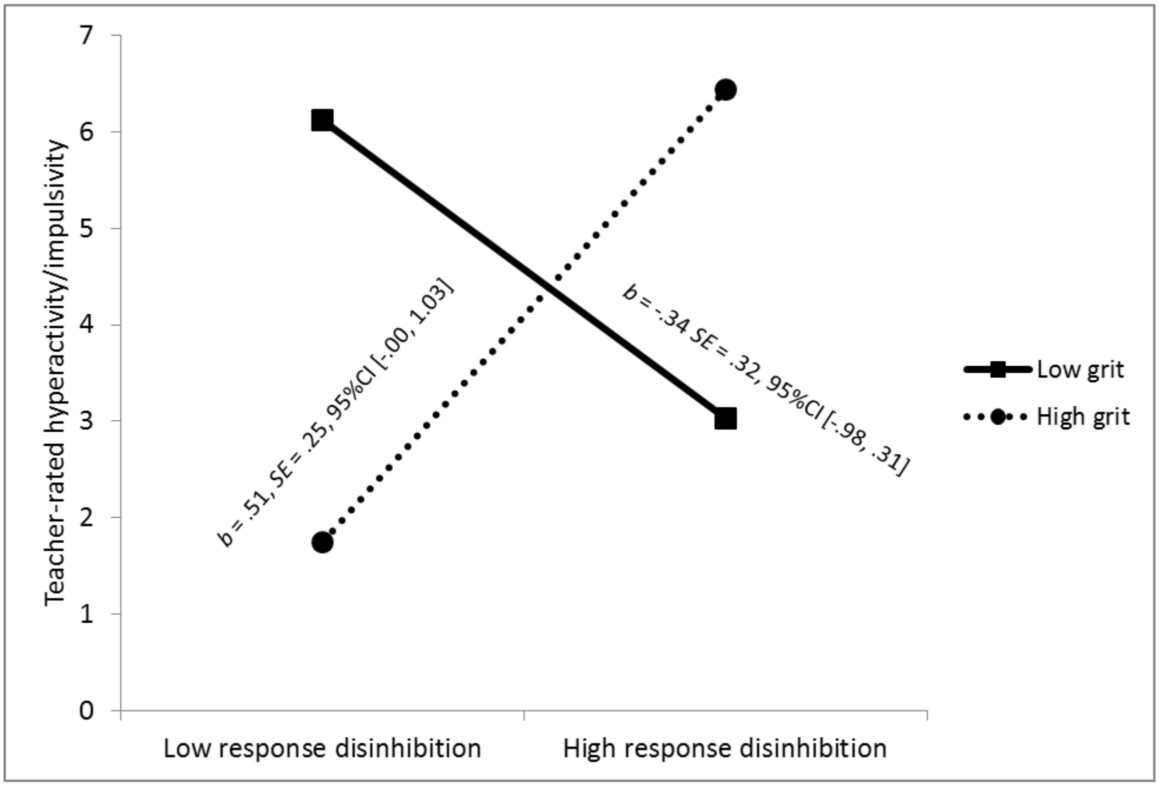

Figure A4. Marginally significant interaction between response disinhibition and child grit predicting teacher-rated hyperactivity/impulsivity.

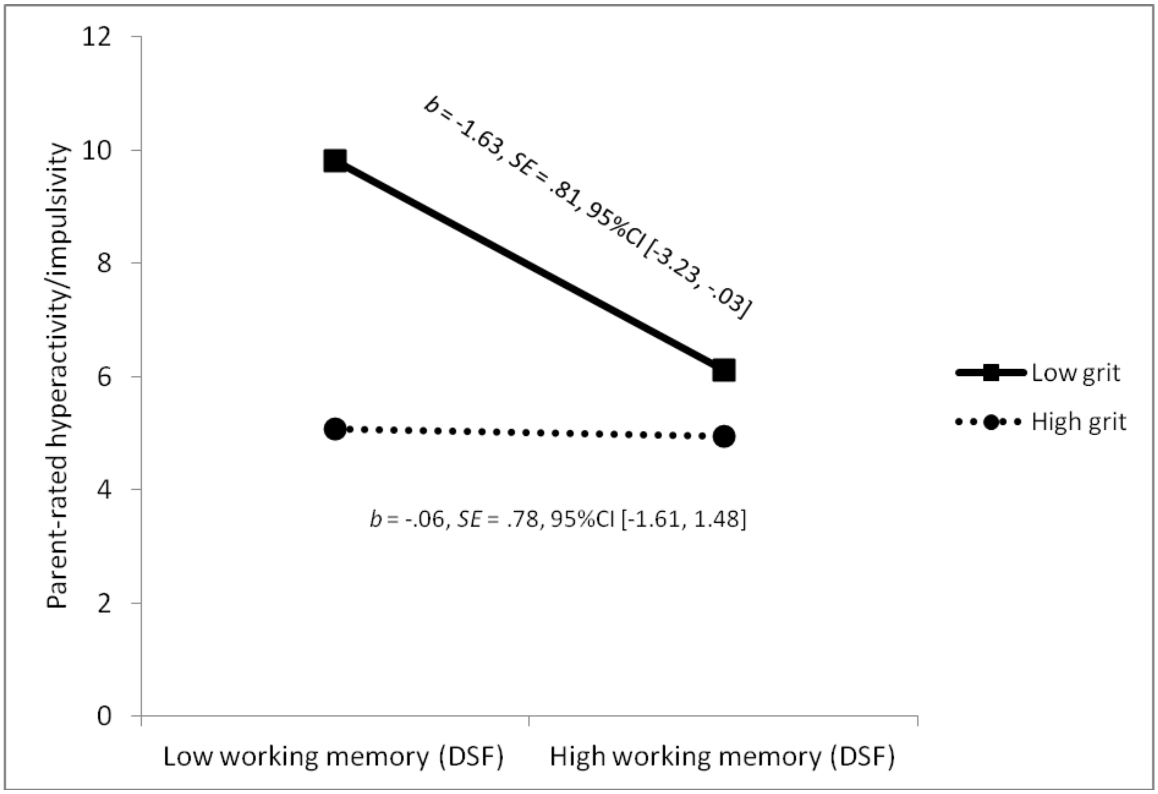

Figure A5. Marginally significant interaction between working memory (DSF) and child grit predicting parent-rated hyperactivity/impulsivity.

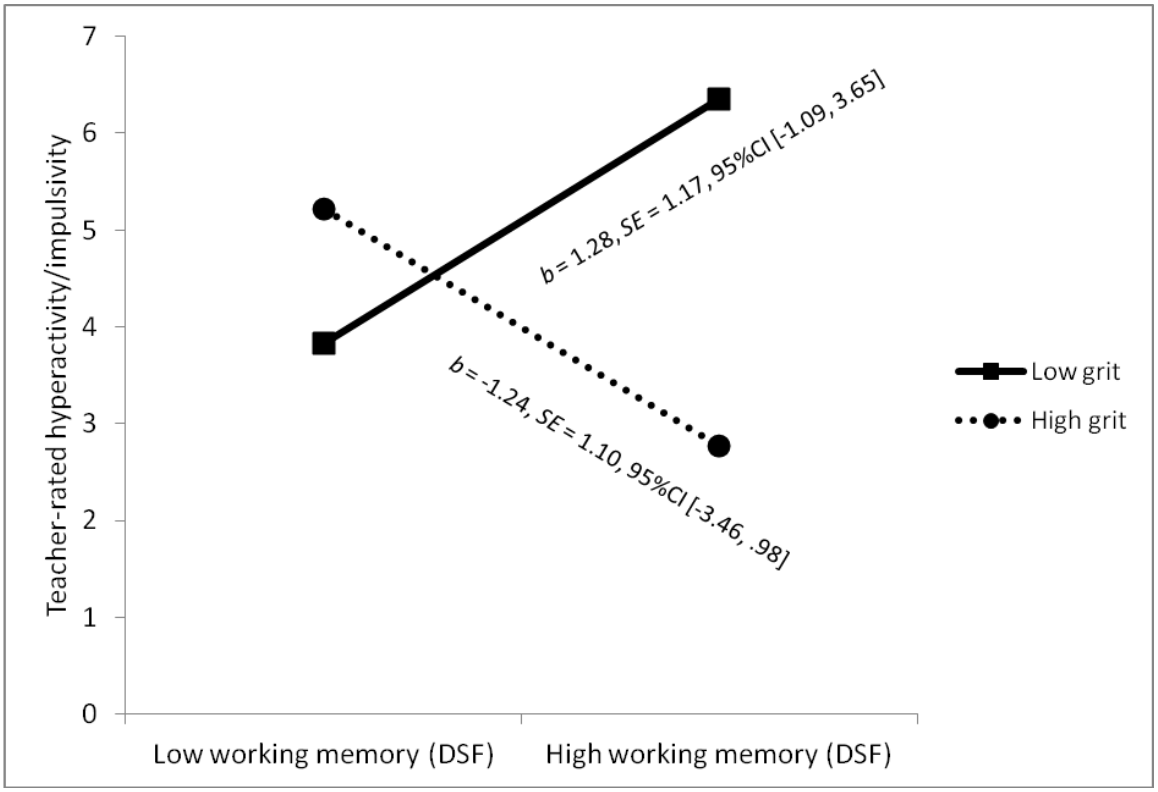

Figure A6. Marginally significant interaction between working memory (DSF) and child grit predicting teacher-rated hyperactivity/impulsivity.

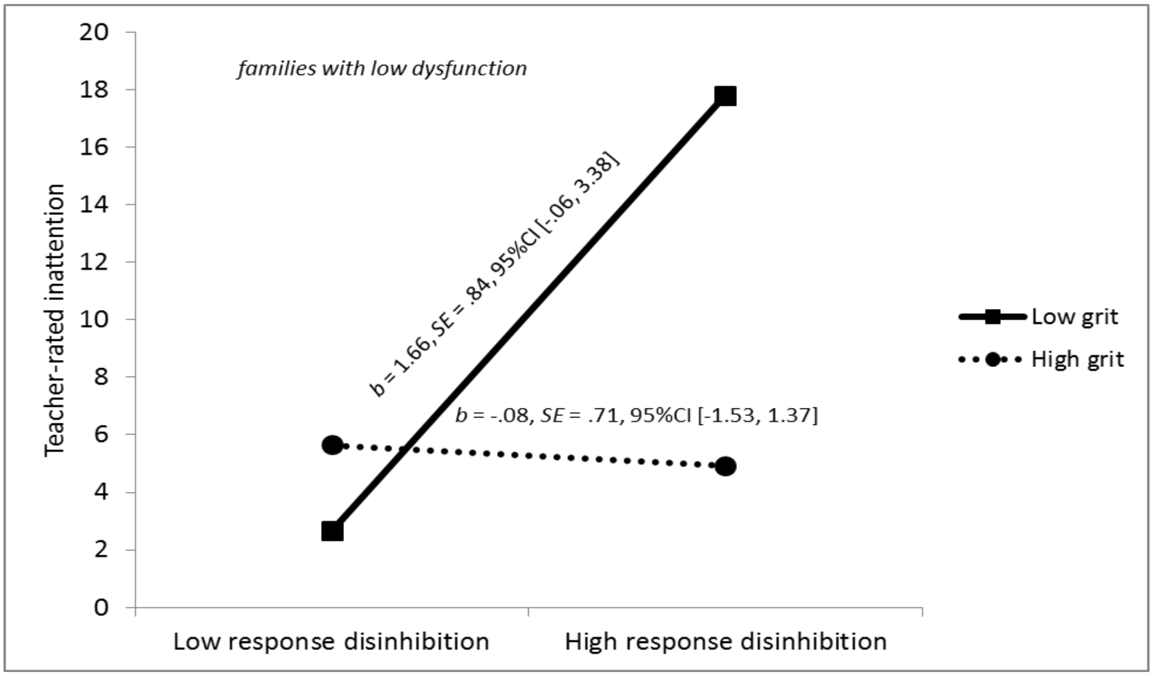

Figure A7. Interaction between response disinhibition and child grit predicting teacher-rated inattention in families with low dysfunction.

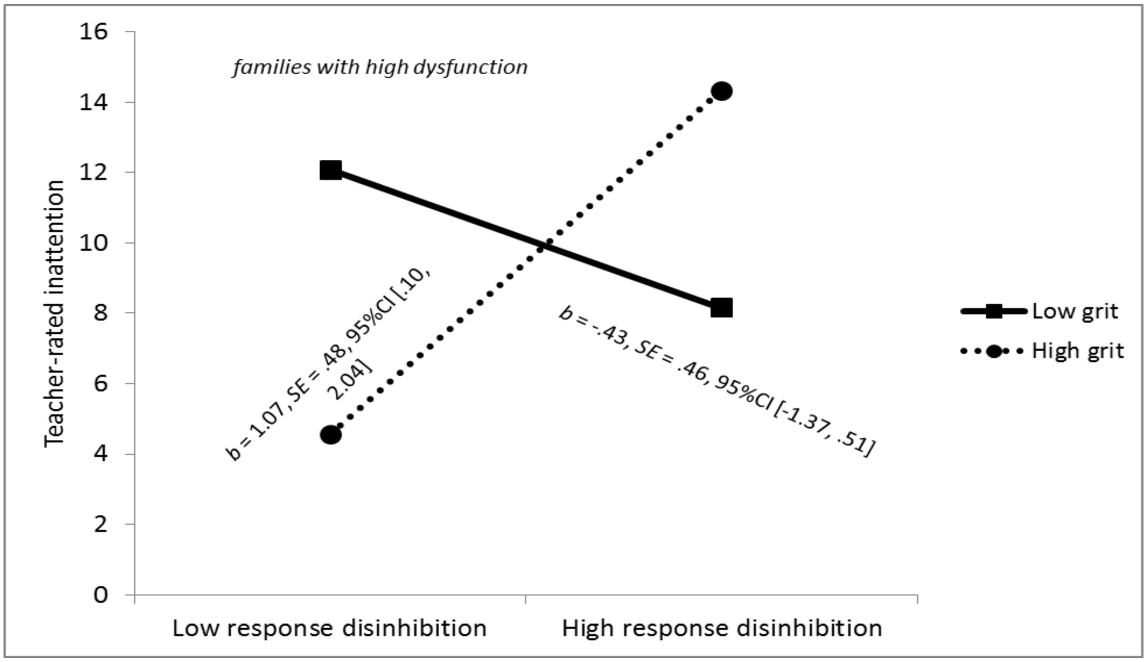

Figure A8. Interaction between response disinhibition and child grit predicting teacher-rated inattention in families with high dysfunction.

APPENDIX C – IRB Approval Letters

THE UNIVERSITY OF
SOUTHERN MISSISSIPPI

INSTITUTIONAL REVIEW BOARD
118 College Drive #5147 | Hattiesburg, MS 39406-0001
Phone: 601.266.5997 | Fax: 601.266.4377 | www.usm.edu/research/institutional.review.board

NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Institutional Review Board in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months.
  Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: 16093008
PROJECT TITLE: Exploring the Moderating Effects of Family Functioning and Child Grit on the Relation between ADHD Endophenotypes and ADHD Symptoms
PROJECT TYPE: New Project
RESEARCHER(S): Karin Fisher
COLLEGE/DIVISION: College of Education and Psychology
DEPARTMENT: Psychology
FUNDING AGENCY/SPONSOR: N/A
IRB COMMITTEE ACTION: Expedited Review Approval
PERIOD OF APPROVAL: 12/01/2016 to 11/30/2017
Lawrence A. Hosman, Ph.D.
Institutional Review Board

THE UNIVERSITY OF
SOUTHERN MISSISSIPPI

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- If approved, the maximum period of approval is limited to twelve months.
  Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: CH4-16093008
PROJECT TITLE: Exploring the Moderating Effects of Family Functioning and Child Grit on the Relation between ADHD Endophenotypes and ADHD Symptoms
PROJECT TYPE: Change #4 to a Previously Approved Project
RESEARCHER(S): Karin Fisher
COLLEGE/DIVISION: College of Education and Psychology
DEPARTMENT: Psychology
FUNDING AGENCY/SPONSOR: N/A
IRB COMMITTEE ACTION: Expedited Review Approval
PERIOD OF APPROVAL: 12/01/2017 to 11/30/2018
Lawrence A. Hosman, Ph.D.
Institutional Review Board

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